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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2779.] *LONDON: FRIDAY, APRIL 4, 1919.* [Registered at the General Post Office as a Newspaper.] PRICE 9d. BY INLAND POST ... 11d.

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Page 122, March 14.

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See Advertisement page 54, March 14. 2480
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See half-page Advertisement page 101, March 21.

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The Technical College, ENGINEERING DEPARTMENT.

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HERBERT REED,
Education Offices, Secretary.
15, John Street, Sunderland. T 723
20th March, 1919.

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THE

University of Liverpool.

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THE METROPOLITAN ASYLUMS BOARD invite

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By Order,
T 847
DUNCOMBE MANN,
Clerk to the Board.

COUNTY BOROUGH OF NORTHAMPTON.

The Corporation are prepared to receive

Tenders for the supply and

DELIVERY of about Nine Miles of 16 inch CAST IRON WATER PIPES.
Copies of Specification and Form of Tender can be obtained on application to Mr. Frank Tomlinson, Waterworks Engineer, Fish Street, Northampton.
Sealed Tenders endorsed "Tender for Pipes," are to be delivered at my Office before Twelve noon, APRIL 15TH, 1919.
The Corporation do not bind themselves to accept the lowest or any Tender.
H. HANKINSON,
Guildhall, Town Clerk. T 833
Northampton.

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Tenders are to be in sealed envelopes, marked "Tender for London Defences," addressed to "The Staff Officer, London Defences," 2, Great George Street, S.W. 1, delivered by Ten a.m., on Friday, 25th April, 1919.
No guarantees can be given that the lowest or any Tender will be accepted.
R. EUSTACE TICKELL, Major,
London Defences, Staff Officer,
2, Gt. George St., S.W. 1. London Defences.
31st March, 1919. T 892

G. R.

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Two Annealing Furnaces, overall 4 ft. 6 in. high, 4 in. by 1 ft. 6 in.
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Telephone: Gerrard 840, Exten. 109. T 887

METROPOLITAN BOROUGH OF HAMMERSMITH.

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(b) HOT AIR FORCED DRAUGHT FAN AND AIR HEATER.
Full particulars and form of tender may be obtained from Mr. G. G. BELL, Engineer and Manager, Electricity Dept., 85, Fulham Palace Road, W. 6.
Sealed Tenders endorsed "Tender for Electrical Plant," must be delivered to me not later than four p.m. on Wednesday, the 9th April, 1919. The Council does not bind itself to accept the lowest or any Tender.
LESLIE GORDON,
Town Clerk.
Town Hall, Hammersmith, W. 6.
1st April, 1919. T 920

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

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Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Spare Parts of Carriages and Wagons," or as the case may be, not later than 11 o'clock a.m., on TUESDAY, the 15th APRIL, 1919.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
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London.
2nd April, 1919. T 934

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Apply by letter to Messrs. C. P. SANDBERG, 70, Victoria Street, Westminster, S.W. 1, giving age, full particulars of education and experience, and copies of testimonials. T 490

ROYAL SIAMESE STATE RAILWAYS.

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the POSTS of WORKSHOP MECHANICAL FOREMEN.
Applicants must be highly trained mechanics, well up in Locomotive building and repair, boiler, smith, foundry and spring work, and oxy-acetylene welding; they must also be capable of successfully controlling men; the engagement will be for three years; salary 350 ticals per month rising to 400 ticals per month—approximately 13 ticals = £1—with travelling and field allowances.
Apply letter to Messrs. C. P. SANDBERG, 70, Victoria Street, Westminster, S.W. 1, stating age, full particulars of experience, and enclosing copies of testimonials. T 491

UNIVERSITY OF LONDON—GOLDSMITHS' COLLEGE.

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Applications are Invited for

the Following POSTS:—
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COUNTY BOROUGH OF HALIFAX.

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PRINCIPAL—J. CROWTHER, B.Sc. (Lond.).

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the POST of ASSISTANT in the Mechanical Engineering Department. Salary £200 to £250 per annum according to qualifications and experience. Teaching experience, including laboratory work and practical experience in an engineering works are essential.
Particulars and forms of application, to be returned as early as possible, may be obtained from the PRINCIPAL.
W. H. OSTLER,
Secretary.
Education Offices,
West House, Halifax.
March 21st, 1919. T 685

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

MECHANICAL ENGINEERING DEPARTMENT.

There are Two Vacancies in

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A new Salary Scale is now under consideration by the Committee. Applicants for any one of the above positions can obtain further particulars from the PRINCIPAL of the College.
Applicants must apply by letter, with copies of three testimonials or references, to the undersigned on or before WEDNESDAY, 30TH APRIL.
HERBERT REED,
Secretary.
Education Offices,
15, John Street,
Sunderland.
26th March, 1919 T 732

DARLINGTON EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

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A. C. BOYDE,
Director of Education and Secretary.
Education Office,
North Lodge,
Darlington,
March, 1919. T 724

LONDON COUNTY COUNCIL.

Whole Time Associate Head

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Candidates should have a good honours degree or its equivalent and have had experience in works and drawing office. Salary £400 a year, rising to £500 by yearly increments of £20.—Apply to EDUCATION OFFICER (T. 1.) Education Offices, Victoria Embankment, W. C. 2 (stamped addressed envelope necessary). Form giving particulars will then be sent. Form must be returned by Eleven a.m. on 10th APRIL, 1919. Canvassing disqualified.
JAMES BIRD,
Clerk of the London County Council.
T 855

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NATURAL GAS MINING AND SERVICE.

The natural gas industry does not seem to be in a satisfactory condition, either from the point of view of the producer or of the consumer. Apparently its fortunes are passing through a transition stage in which the wasteful and extravagant methods of the past, encouraged by large volume and low price, after having exercised their baneful effect, are being exchanged for a sounder policy whose adoption has been imposed by visibly diminishing output and the rising price that scarcity inevitably necessitates. True economic policy requires that legalised and regulated collective operation should be substituted for the haphazard or selfish competition of individuals, whose action is fast exhausting an irreplaceable fuel, that is capable of serving many domestic and industrial purposes. A system, or want of system, that immediately benefits the individual by tolerating unrestrained and profitless appropriation, is not easily replaced by a sound and correct policy that will safeguard the public interest and prolong the supply for future generations. The awakening of public opinion is a necessary preliminary measure, if a successful contest is to be waged against present selfishness, but the local character of the industry and service places a difficulty in the way of overcoming the evil originating in past indifference. Unfortunately a confined and provincial aspect of the general problem has been allowed to prevail over the broader view which would protect the national interests on a larger scale. The presence of a migratory and fugitive product, like natural gas, in a particular State, as Ohio or Pennsylvania, is an accident, a fortunate accident for those particular States in which it is proved to be abundant, but if all the available elements existing in any natural resource are to be utilised to their utmost, it must be recognised that all branches of industry are dependent upon each other and that equal progress along the whole line of industrial life must be the object sought. With the need of promoting healthier conditions and of preserving a valuable asset whose useful existence is jeopardised by reckless disregard of future circumstances, the United States National Museum has issued a report* by Mr. Samuel S. Wyer, which depicts the present position of the natural gas industry, examines its method of service, and urges the necessity for legalised conservatism. In view of the gravity of the problem, the National Museum proposes, as a further means for quickening public interest, to arrange an exhibition which shall visualise the critical features of the situation in a direct and effective manner.

The task of attracting public attention is the more difficult as owing to the distribution of the gas-fields throughout the Union, only a comparatively small portion of the inhabitants are directly concerned in their rational development. This proportion is shown in Fig. 1, where a few States, of which Ohio and Pennsylvania are the most important, possess 72 per cent. of the known supply. Seventeen other States divide the remaining 28 per cent. among them, and beyond this limit no gas is found. General legislation under such circumstances is difficult, and action in the State Legislatures is likely to prove unavailing, if not, harmful. Each State endeavours to keep its natural resources within its own boundaries as a means for increasing the incentives to settlement within that State. In many cases, "boom" towns in the gas-fields have held out the inducement of supplying either free gas, or the gas has been sold at ridiculously low prices to industries willing to locate. In West Virginia alone it is estimated that there are more than 4,000 free consumers, and to allow free consumption is not the way to foster economy. Another plan devised with the same intent of specious bribery is to levy a distinctive tax upon the transmission of natural gas, discriminating between gas consumed within the State as against that transmitted for consumption outside its boundaries. This mistaken policy of limiting the area to be supplied can be made effective in a more artful manner by restricting the pressure in the main lines within such limits, that satisfactory interstate transmission is impossible. For it must be remembered that pressure is the crux of the whole problem. The method of transmission demands that the gas should be delivered at a pressure sufficient to force it through the line. When the initial pressure fails compression has to be employed, a process that increases the cost very materially. It might be possible to market the gas without increasing the pressure by employing pipes of large diameter, but the cost would be prohibitive. To increase the pressure in proportion to the distance the gas is carried—the only economical way of handling the problem. The gas compressor performs a function somewhat similar to that of a step up transformer for an electrical transmission line. The part played is equally important, and limitation of pressure can exercise a very harmful effect on gas transportation. Mr. Wyer contends that a particular State is no more justified in preventing, or indirectly burdening, the exportation of natural gas than in applying the same restrictive measures to the transportation of food. A careful examination of State Rights would be necessary to dispose of this contention, but if the gas output is insufficient to secure, or other causes interfere with the maintenance of, a constant supply to towns comparatively adjacent to the fields, there is little reason to urge a wider and more extensive distribution.

From the occasional inability to supply towns at a distance with gaseous fuel, it must not be concluded that the industry is therefore small, or in its infancy. Some ten millions of the inhabitants of the United States are more or less directly concerned in the issue, and indirectly the nation-wide problem of fuel supply is closely involved in the solution of this question. Of the capital invested we have little information, but there are more than 220 natural gas compressor stations in North America, aggregating approximately 350,000 h.p. of compressor capacity and compressing about 90 per cent. of all the natural gas used. It is to be regretted that the report adheres strictly to the economical question, ignoring the examination or description of the mechanical features and details involved in the conduct of the industry. From an engineering point of view this is especially unfortunate, for not only does the distributing plant differ in essential respects from the ordinary public utility service but by reason of the age and magnitude of the operations, many devices must have been introduced and adopted that would have repaid study. We have to content ourselves with pictorial illustrations of natural gas compressing stations, indicating the necessity of very extensive plant and of gas main lines in construction that suggest the successful conquest of initial difficulties, but these excite rather than satisfy curiosity.

The popular notion that natural gas completely fills spacious caverns or huge crevices in the rocks, that operate as natural gas holders, is a misconception. Oil and gas sands are simply very porous rocks which retain the gas in many millions of miscroscopic voids, so that the gas, often accompanied by oil and water, occupying there numerous little spaces, completely separates the rock. The larger the pores and the greater the volume they occupy in proportion to the volume of the rock mass, the greater will be the contained gas supply, and as a rule this proportion varies from one-fifth to one-tenth. The gas-pressure, upon whose importance we have already insisted, is due to the compression into these fixed rock spaces of a larger volume of gas than the mere free air capacity of this rock reservoir. It is evident therefore since the amount of gas confined in the sands is limited, that the removal of any portion of the gas from the reservoir will be accompanied by a fall in the pressure, owing to the same extent of space being occupied by a smaller amount of gas. Under working conditions, therefore, the decline of rock pressure is inevitable and continuous. This is illustrated in Fig. 2, where the initial pressure of two wells in 1913 is contrasted with the reduced pressure of each five years later. The serviceable life of a well is limited by its decline in pressure, but this life is further curtailed, since as a matter of fact only about 25 per cent. of the "open flow" capacity is the utmost that can be delivered from the average natural gas well. By "open flow" is understood the entire volume of gas that will issue from the mouth of a well, when retarded only by atmospheric pressure. Natural gas is therefore a wasting asset, one demanding watchfulness and care, the more especially as the number of consumers is increasing faster than the number of producing wells. Not only is an additional burden placed on each well, but the wells that are being drilled at the present time have a lower average capacity than the wells that were drilled several years ago, consequently making less gas available. In the case of a particular company operating nearly 40 per cent. of

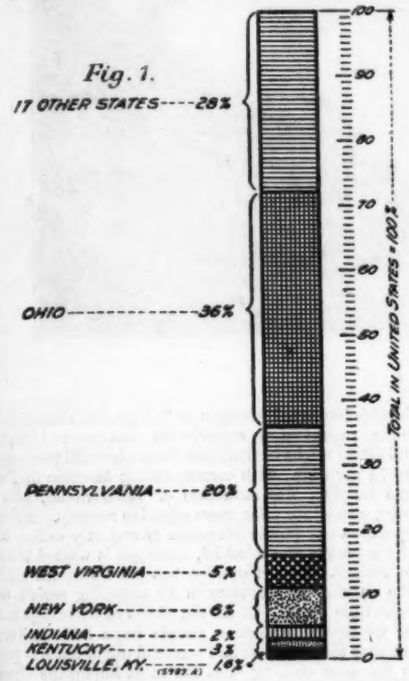


Fig. 1.

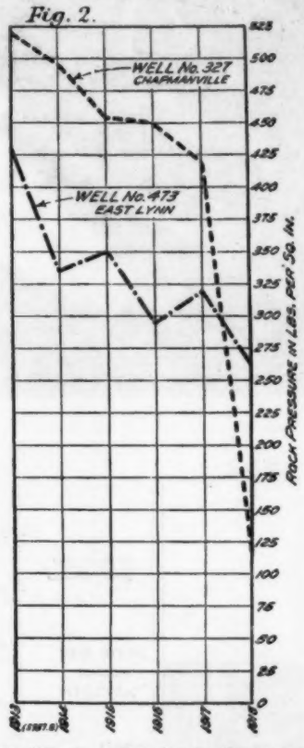
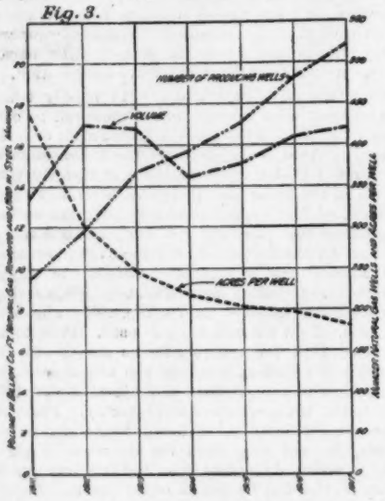


Fig. 2.

* United States National Museum. Bulletin 102, Part 7. *The Mineral Industries of the United States, Natural Gas; its Production, Service, and Conservation.* By Samuel S. Wyer, of Columbus, Ohio. Washington: Government Printing Office.

the entire output of one State, statistics show that the number of acres of gas land available to each domestic consumer sank from three acres in 1910 to two acres in 1917. Further, representing by M, 1,000 cubic. ft., the general unit of gas measurement, the average open flow of new wells drilled declined from 1,200 M. in 1913 to 700 M. in 1917. Put in another way, the average annual production of a well declined from 3,600 M. in 1910 to 2,200 M. in 1917. Expressed in diagrammatic form the general bearing of this statement can be seen in Fig. 3.

Fig. 3.



The effect of rock pressure and the imperative necessity for its conservation as far as possible is more clearly seen if the difference between the gas service and the oil industry are contrasted. This distinction is the more desirable as the products are frequently associated in the same district, and the raw products may have had a common or at least a connected origin. Although gas when found in the same field as the oil may be utilised by the oil operators, it is more frequently regarded as a nuisance, and the gas "blown off," or wasted, in order to reach the oil more rapidly. The injury inflicted on the gas supply can hardly be overrated. Fig. 4 shows an extreme case of this wasteful method, though the aggregate wastage from smaller and less sensational causes must be far greater. But the gas output, when carefully treated, differs from that of the oil mainly in its manner of collection. Oil is capable of being transported to any distance and every oil well can be utilised, no matter how small its product may be so long as its yield pays more than the cost of producing the oil. The profitable exploitation of the natural gas is very different. Once tapped at its source in a gas sand formation, it cannot be gathered or stored, except by the very limited use of existing gas holders in distributing plants. When found in sufficient quantity and under sufficient pressure, it is turned at once into the transmission line and the pressure at the mouth of the well is the moving force by which it is driven through the line to the consumer. When the pressure fails through distance, recourse must be had to compression, an expensive but necessary procedure. A very material difference from oil collection occurs when the pressure at a given well falls below that in the line with which it is connected, for in that case the gas from that particular well cannot enter the line, but will be driven back by the superior force it encounters at the point of connection. The pressure may be sufficient to serve a market near at hand, but in the absence of such favourable conditions the gas is valueless, unless the demand is sufficient to warrant the expenses of compression.

There is little room for increasing the value of the product by technical treatment. Natural gas is a crude mineral not capable of being advanced in value or condition by refining, or purifying, or by any process of manufacture. The product may, and does, differ widely in its constituent elements. Some gases may obtain abundant gasoline and others little, the calorific value may vary considerably, but whatever its original condition, so it is supplied to the consumer. It is not found commercially feasible to correct any variation in quality by artificial means or to attempt to furnish a uniform gas as may be done with manufactured gas, for the simple reason that the cost would be much more than the additional value of the service would warrant. It must not be supposed, however, that the accidental variations in the quality of the gas introduce no difficulties in transmission. Owing to changing temperature and pressure, part of the contained vapours may be precipitated as liquid, choking the line, and if water be present it may freeze and block the line completely. These troubles are likely to increase with the time the well is in use, but such losses must be borne by the management and do not effect the general conditions of the industry. Interruptions in supply must, however, be inconvenient when the gas is used for industrial purposes and at present, of the entire gas consumption only about one-third is required for domestic purposes as shown in Fig. 5. Auxiliary heating equipment is recommended as the remedy for such occasional interruptions, which apart from the physical causes mentioned may be due to the "peak period" of the load. Such cautions warn us of the incompleteness of the service, of the necessity of overhauling the entire system, and of adopting improved measures of conservation. Incidentally the value of the gas holding reservoir is demonstrated.

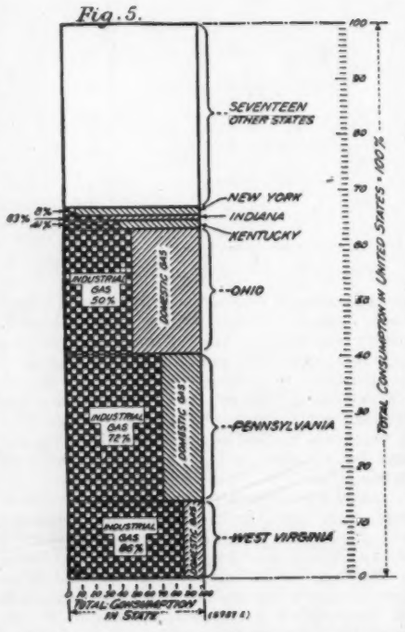
There are two directions from which amelioration may be expected. The reduction in waste and increased efficiency in the gas-using equipment. When the supply was greatly in excess of demand, there was little inducement to manufacturers to furnish improved furnaces or fittings, but those days have passed and experiment has proved that efficiency might be increased from about 30 per cent. to 75 per cent., with corresponding decrease in the gas supply. The reduction of waste would, however, constitute a far more effective remedy. Even to-day when public attention is urgently called to the extent of the mischief, more gas is wasted than is utilised. Expert opinion has put on record that the natural gas industry is an appalling record of incredible waste. Of all the pieces of extravagance of which the American people have been guilty, perhaps their reckless and wasteful use of natural gas is the most striking—not the most important—but the most striking. This product, severely limited in quantity, which can last only a few years at most, has been handled by them as if it were illimitable.

We have already referred to the excessive waste of gas resulting from attempts to reach the oil quickly, a practice that has been the main cause of the depletion of many gas fields, and the loss from this cause is readily appreciated, but it is necessary also to bear in mind the hourly and daily waste that is regarded as inevitable and attracts little attention. When reduced to figures, however, the loss is seen to be very striking. In actual tests on more than 1,000 wells in West Virginia, it was definitely established that the average waste of natural gas at each well was 12,000 cubic ft. per day. There are at least 16,000 oil wells in the State, and consequently the annual total waste amounts to approximately 70,000,000 m. cubic feet, equivalent to about one-third of all the natural gas used for domestic consumption in the United States. Yet Fig. 1 shows that West Virginia contributes only 5 per cent. of the total supply. To get the grand loss from the use of improper casing and similar causes the large figures just quoted must be multiplied by twenty.

Leakage due to imperfect structural conditions of main lines is responsible for the loss of much gas, and where there are no proper devices for measuring and checking the loss, an enormous waste occurs on those lines that are supposed to be gas-tight. When the system of checking is maintained, it is found that the leakage loss amounts to 19,000 cub.

FIG. 4.

Fig. 5.



ft. per year for each house supplied. This loss is excessive, but the remedy is in the hands of the producers, who have been as little careful of the commodity they dispense as the users themselves. In the case of new lines where the welded process is feasible, gas mains are being welded. And again what is cheap will not be saved or treated as valuable, and those having free gas service privileges, by reason of having gas wells or gas lines on their farms, exhibit incredible extravagance, increasing the consumption to an enormous extent. On the most trustworthy evidence it is proved that the average consumption of each privileged consumer amounts to 480,000 cub. ft. per annum, as compared with an average consumption of only 53,000 cub. ft. for each domestic consumer supplied in towns by regular service.

In presence of such figures, any complaint against the "carbon black" manufacture seems out of place. This use of the gas may be regarded as legitimate, and there is some return for the gas expended. "Carbon black" is the trade term applied to the deposit on a metallic surface, when brought into actual contact with the gas flame. About 1½ lbs. of carbon black are obtained from each 1,000 cub. ft. of gas burned, but it would appear that no use is made of the heat. This is unfortunate, for the carbon black manufacture is large, requiring 26,000,000 m. cub. ft. per annum, or the equivalent of one-eighth of the entire quantity of natural gas used for domestic purposes in the United States. A larger deposition could be collected with better designed appliances than is possible with the methods of incomplete combustion hitherto adopted, and on this ground the continuance of the primitive methods is objectionable, but on the other hand, Mr. Wyer, who is no friend to this particular trade, admits that carbon plants have been located on sites where, with the present prices ruling for natural gas, it would not be feasible to lay down lines that would make the product available for public utility transmission. Oftentimes, too, the manufacturing plant is placed so close to the quitting wells that it is possible to utilise pressures so low that the transmission companies could not profitably convey the gas to compressor stations. In such positions, the carbon manufacturer is clearly using a waste product and cannot be held responsible for undue loss.

All these sources of waste are, however, dwarfed to insignificance in comparison with that which arises from injudicious drilling, bringing about so great a reduction of pressure throughout wide areas that large quantities of gas cannot be utilised. The keenest struggle is going on between the reckless demands of the present and a prudent conservation for the future. The small producer, intent on getting a supply of gas for his immediate needs and profoundly indifferent to future requirements, will drill wells on land of less than an acre in extent, and there seems to be no competent authority to restrain such imprudent proceedings. The consequence of permitting this ill-regulated conduct is easily seen. A good well may be properly located and gas profitably collected from it, but the effect of putting down a second well in close proximity, technically an "offset well," may reduce the pressure of the first to such an extent that its value is utterly destroyed without getting sufficient pressure at the second well to ensure transportation of the gas. Division has the effect of crippling both wells. The future continuity of service to the gas using public is rendered possible only by carrying a reserve acreage for future drilling operations. From statistics supplied by the Geological Society of the United States, it appears that in 1916 gas producers carried an average of 313 acres for each producing well, but this acreage varied greatly in different localities. One company re-sowed 1,250 acres per well in 1917, but in 1910 the same company was able to reserve 5,500 acres for each gas well.

The reduction of reserve acreage per well shows that it may be legitimate and even necessary to put down new wells as a protective measure, but the selection of the conditions that warrant supplementary drilling and protect both the interests of the public and those of the investor is a difficult matter to determine. The adventitious origin, migratory habits and fugitive tendencies of natural gas, as well as the nature of the sand and the topography of the country, are all factors that complicate the issue. Certainty can never be attained without experiment, and generally, costly experiments. As the result of experience it is estimated that only one well drilled in four is remunerative. Offset wells are frequently dry, mainly because the original wall, drilled in the most promising position, has drawn off the gas from a local port and the second well falls outside the limits of gas collection. But if the sand reached by drilling an offset well prove to be of the same porous nature as that originally penetrated, the gas output will probably fall short of that from the original well. For when the first well is drilled into the pool, the rush of gas from the high rock pressure has a marked tendency to open up numerous channels of low resistance in the rock formation, so that the gas in the sand and porous rock can get to the well opening with a minimum of friction. The high initial rock pressure aids substantially in first creating such lines of least resistance, and then in freeing them of loose particles of sand which are blown out through the well.

To tap a well successfully often means drilling for half a mile below the surface, and such a task is not undertaken lightly. The prospect of easy drilling offers an inducement to carry on operations in situations that geological and topographical surveys do not indicate as the most judicious. But the search for new wells requires an oversanguine temperament on the part of the prospector, and the inducement must be comparable with the risks. The speculative element in human nature will effect much and tempt men to hunt for new gas supplies, but when the losses are greater than the gains the search will cease. Mr. Wyer's discussion suggests that this time has arrived or is near at hand. The inevitable disappearance of this serviceable fuel may be delayed, but not prevented. The prudent man works for delay, a result that will be promoted by bringing exact knowledge to assist systematic development on scientific lines. Government action and control can also be summoned in aid. The greatest need of the industry to-day is a policy that will secure the mandatory pooling of the field operations, a policy that would ensure the least waste with the smallest cost. Operators must act in unison for the protection of their common sources of supply and for their mutual benefit. Education of the natural gas producers and of the general public is also needed to furnish protection against ignorance and inefficiency, or possible fraud. The lesson may be hard and unpalatable, but the author is justified in claiming that the only policy that will effectively conserve the supply for future use and thereby ensure continuity of service, is the demand of an adequate price, commensurate with the worth or value of the service. The public is best served when natural gas mining is made profitable.

THE INSTITUTE OF METALS.

(*Concluded from page* 414.)

THE second day's proceedings of the annual meeting of the above Institute were held in the rooms of the Chemical Society at 4 p.m. on the 26th ult. The President, Professor H. C. H. Carpenter, was in the chair.

ALUMINIUM AND ITS ALLOYS.

The first paper dealt with was one by Messrs. D. Hanson and S. L. Archbutt entitled "The Micrography of Aluminium and its Alloys." The paper, which we reprint in this issue (see page 450), was read in abstract by Mr. Archbutt.

Dr. A. G. Gwyer opened the discussion. He said he felt they owed a debt of gratitude to the authors for their most able paper. He was working with the same classes of soft material himself daily, and knew the difficulties of obtaining good results. The authors' micrographs were wonderful. The procedure he adopted in preparing specimens was much like that described by the authors. He found, however, that "000" emery paper was not satisfactory to finish with, "00" or "0" were better. He always flooded the paper with paraffin, and had not been able to get anything out of the paraffin wax method. For finishing, metal-polish and selvyt were used. Figs. 2 and 3 in the paper were very interesting as showing the $FeAl_3$ and silicon so clearly differentiated, but he would ask the authors if they had ever seen anything like this in worked metal. It could be seen in castings, but in worked metal the silicon was always in solid solution. In connection with etching with hydrofluoric acid, he would say he always used the solution very weak, adding the acid drop by drop, and requiring 8 minutes to 10 minutes for the etch. He was glad Fig. 9, showing a tarnish on the section, had been included in the paper. It was like what one too often got, and accentuated the remarkably good quality of the other figures. The technique of this subject was extremely difficult.

Mr. F. Johnson, the next speaker, said that had the paper appeared a little earlier, it would have been of great assistance in connection with some work being carried out at Birmingham during which it had been found difficult to distinguish between silicon and Fe Al_3. From his own point of view, he would say that the figures in the paper were exactly what he had been looking for for a long time, and would be of great value for teaching purposes. In connection with the method of mounting specimens illustrated in Fig. 1 of the paper, he should have thought at times there might be danger of electrolytic action during etching, also there would be wear, and it might be difficult to keep the clamp level. He doubted if it could be used for copper at all. His method was to mount thin strips in sealing-wax. It was very successful; there was no electrolytic action and no trouble. On the question of polishing, he would ask if the authors had ever used parchment to finish with. Finally, referring to Fig. 9 of the paper, the authors suggested the dark parallel markings were produced during grinding. These marks were similar to what had been found in rolled copper, and he suggested they were due to rolling.

Professor T. Turner said that at Birmingham they had used parchment, and also magnesia powder for polishing for some time. It was not difficult to obtain excellent photomicrographs of alloys, the difficulty was in explaining exactly what they represented, and if the paper had been available earlier, it would have been of great service in connection with work they carried out at Birmingham.

Dr. C. H. Desch said that all who had worked with aluminium alloys had no doubt noticed differences between the $FeAl_3$ and the silicon in structure and form, but difficulty had been in deciding which was which. The paper put the subject of the microphotography of aluminium on an entirely new footing. On the subject of final polishing, he would say he used metal polish and selvyt. It was necessary, however, to rub the specimen finally for a considerable time with clean selvyt, to make sure of getting rid of all traces of the polish. He had ceased using magnesia powder, because of the difficulty of caking mentioned in the paper.

Miss M. L. V. Taylor stated that she had used both paraffin and wax for the emery-cloth polishing, and had found waxing much better than flooding with paraffin. Her experience also was that selvyt was no good for soft alloys. Chamois leather was all right.

Mr. E. L. Rhead said that hand polishing was by far the best for soft alloys, and that results were more quickly obtained. For finishing, Persian leather was better than selvyt, parchment or any of the other materials.

Mr. L. Archbutt said he had done nothing with light alloys himself, and could not make any technical criticism of the paper. He merely wished to ask if a trial might not be made of petroleum jelly for the polishing operation.

Dr. Walter Rosenhain said that in connection with the use of magnesia powder, which had been mentioned in the discussion, he thought he was responsible for its introduction for polishing microsections some years ago. Its advantage was that it gave a very close scratch. The particles were very small, and sharp. There was no flow such as one got with rouge. He thought it was worth using even with steel. The caking could easily be avoided by proper washing arrangements.

Mr. F. C. A. H. Lantsberry said the paper was

very useful to people like himself who had to deal with works practice. He would like to see more papers of its type. With reference to a reagent which would darken the manganese-aluminium compound $MnAl_3$, he would suggest that hydrogen peroxide might be tried. It was capable of darkening complex manganese compounds in high-speed steels.

Mr. P. Peakman referred to the mounting of very thin specimens. He filled a brass tube, say ¼ in. diameter, with shellac, and then by softening the shellac at one end embedded the specimen in it. It could then be dealt with with ease. He had examined both cross and longitudinal sections of a metallic lamp filament by this method.

Professor Carpenter said this was by a long way the best paper that had appeared on the subject. In dealing with microphotographs; one was concerned with two points—to examine for impurities and to bring out the structure. The authors were mainly concerned with the first of these aims, and had been wonderfully successful. Miss Elam and the speaker had been carrying out an investigation to develop the boundaries of the structure of aluminium as free from impurities as possible. It was much easier to carry out such work on alloys than on pure aluminium. This was illustrated by Figs. 10 and 8 in the paper. Fig. 5, however, showed an entirely different state of affairs; many crystals were not in focus, some were deeply etched, others not. Miss Elam and himself had found the same thing. They were dealing with the re-crystallisation of aluminium sheet, and would not be able to make any progress if they had not been able to improve on Fig. 5. Fortunately, they had been able to do this, with pure aluminium. From the point of view of impurities, however, the paper was most successful. Fig. 7 was a masterpiece.

Mr. J. Dowrance said that before starting to polish it was very important to see that one had not damaged the structure in cutting. He had done a good deal of this work with white-metal, and found it very easy to damage the structure with a blunt file. It was necessary to start from a piece of metal that had not been strained in any way, and then use very sharp tools for cutting. If this was done, no great amount of polishing was necessary.

Mr. D. Hanson, replying to the discussion, said that he wished to begin by stating that the success of the micro-photographs was almost entirely due to the skill of the people who were mentioned at the end of the paper. It would not be possible to deal with all the points raised in the discussion at the moment, but he might refer to one or two. Professor Carpenter had mentioned the difficulty of showing the structure of pure aluminium as compared with the harder alloys. The difficulty was due to the difference in level of the various crystals, and the effect was much less in alloys. In duplex alloys it was usually not difficult to find a reagent which would pick one out, the difficulty was that in endeavouring to reveal both you might dissolve one out altogether. He thought the paper had been successful in avoiding this trouble. Dr. Gwyer had mentioned that he preferred to finish specimens with "00" emery paper rather than "000." He thought most people would agree that "00" was better, but still "000" was used. Referring to silicon in worked metal, he thought he had seen it, only in worked alloys. Silicon, of course, was more or less soluble. In connection with Mr. Johnson's sealing-wax, he would say that they had adopted various methods for dealing with their specimens, sealing-wax included, but in general they had not proved very satisfactory. The clip that they recommended has been very successful. Thin specimens could always be treated by plating, but the operation was rather tedious.

Work and Cold Rolling.

The next papers to be dealt with were one entitled "The Effect of Work on Metals and Alloys." by Mr. O. W. Ellis, and one entitled "The Influence of Cold-Rolling upon the Mechanical Properties of Oxygen-Free Copper," by Mr. F. Johnson. The papers were read in abstract by their authors. We reprint Mr. Johnson's paper on page 454.

Sir Thomas K. Rose opened the discussion. He said the papers were of great interest to him and to all concerned with cold-rolling. It was a subject we didn't know enough about. He did not believe that anyone really knew why he adopted the system he did. Mr. Ellis at the beginning of his paper, said "Many of the phenomena that confront us in the study of the properties of the cold-worked hard metals and alloys might possibly be rendered explicable by a consideration of the properties of the cold-worked soft metals and alloys." He did not question this, but when using tin and lead it had to be remembered that they annealed at very low temperatures. Their behaviour on rolling was more like that of hard metals at high temperatures than hard metals when cold. Tin after rolling, for instance, was hard, but it turned soft merely by being left alone. He was prepared to accept Mr. Ellis's hypothesis about the breaks in the curves, but in mentioning Alkin's work he was sorry he did not refer to Alkin's suggestion that before the break in the curve there was no re-crystallisation, but that above it there was. He (the speaker) did not know if this idea had been turned down, but if it was true, then Mr. Ellis's statement "there is a continuous tendency towards re-crystallisation of the amorphous phase at all stages of reduction," did not fall into line. Mr. Ellis suggested that this re-crystallisation will occur at any temperature. According to Alkins it did not. He (the speaker) thought you would get re-crystallisation in time, but some of his own work seemed to suggest that you did not. Turning to the curve in Fig. 12, referring to rolling, he would like to know what width of bar was used. He did not suggest that the curve was not substantially correct, but it should be borne in mind that two or more lighter pinches took less power than one heavier one. For example, in a case he had tried—a reduction from 0·400 to 0·060, *i.e.*, 80 per cent., with four pinches took 113 electrical horse-power, but with nine pinches only 95 electrical horse-power. This effect might modify Mr. Ellis's curve. In his table the third pinch was from 1·102 to 1·040, that was 5·62 per cent. reduction, but the next pinch was 6·73 per cent. reduction, and the next 7·21 per cent., and these pinches determined the shape of the curve at the break.

Dr. Walter Rosenhain said that the attribution of his results to the presence of cuprous oxide by Alkins had been disproved by analysis. The content of cuprous oxide proved to be much less than had been supposed. With regard to the break in the curve, Mr. Ellis's hypothesis was interesting, but there was no definite evidence that this re-crystallisation could take place at ordinary temperatures. There certainly was some indirect evidence as, for instance, in the case of iron, which after overstrain would recover in some hours. We did not know, however, if copper had this property. If so, the time of recovery would probably be very short. Glass was the case of a substance which at ordinary temperatures would not crystallise in many centuries. The hypothesis of the amorphous phase of metals had never been proved, although there was some evidence as, for instance, of amorphous iron being formed during overstrain. In time there was re-crystallisation, and it was possible that artificial ageing might have a similar effect. If polished copper was strained, however, and watched, one saw slipping and twining, but no re-crystallisation. The difference between the power required for a reduction in one large pinch or several small ones, referred to by Sir Thomas Rose, might, however, have something to do with re-crystallisation. With a number of light pinches one would give the amorphous material time to re-crystallise. Finally, he would say that the curves presented by Mr. Ellis wanted many more points determined to establish them properly.

Mr. A. J. G. Smout said that in an investigation on rolling he had made some time ago, he found that the speed of rolling affected the Brinell number. The more slowly one rolled the higher was the number. He wondered if this effect had been taken into account by Mr. Ellis. For instance, dealing with a 28 : 72 brass, annealed at 650 deg., and reduced 33 per cent. in thickness, it was found that with the rolls running at 10 revolutions the Brinell number was 151, but with the rolls running at 14½ revolutions it was 104. At 46 per cent. reduction the figures were 10 revolutions Brinell number 171; 14½ revolutions Brinell number 163. The effect was even more marked when the breaking-down rolls which ran at 7½ revolutions were used. In this work the surface was removed before Brinelling to avoid scale, &c. This was important, and he would like to know if Mr. Ellis had done it. Some of the work done on this 28 : 72 brass supported the hypotheis given by Mr. Ellis at the end of his paper to the effect that the less the initial thickness, the lower the point at which the critical range of deformation commenced. It was found that the thinner the strip the less percentage reduction could be effected without ill effect.

Professor F. C. Lea said he could not speak on the papers directly, as he had not had an opportunity of reading them. He had, however, done much work on the cold-drawing of steel tubes. It was found that if you overstrained steel the specific-gravity actually diminished, but that with time it recovered again. The change went on for some time, it might be a week, or three weeks. It could also be shown that mild steel under torsion had a hysteresis loop. If one went a little beyond the elastic limit the loop became much larger, but if you heated it or left if for a week or so, the material went back to its original state. Another case bearing on the same matter was in connection with the drawing of steel tubes. If the tube was tested immediately it had come out of the die it had a very low elastic limit, but the slightest treatment raised it considerably. No change in atomic structure could, however, be found. Possibly the crystals were surrounded by amorphous matter which was re-absorbed. Another example he might mention was in the forming of tubes of oval section. These were made from round tubes, and if the round tube was put in the oval dies immediately it had been drawn, it was found possible to make it fill them easily. If the round tube had been drawn some time before, however, it was found almost impossible to make it fill the oval dies.

Mr. J. R. Johnson referred to Mr. F. Johnson's paper. He asked why Mr. Johnson had not used a piece of best American wire bar for his experiments. He had found it impossible to remove the last traces of sulphur from cathode copper. He was surprised too Mr. Johnson could find no oxygen in his sample, after the method of treatment with carbon only on the surface. He thought the small weight of material which had been dealt with was to be deprecated, also that the areas of the test pieces were not given. They must have been very small towards the end. He agreed with Mr. Johnson that the Brinell test was unreliable on these specimens, about ⅛ in. was the thinnest it gave reliable results for. The auto-punch test was of no value for thin pieces.

Dr. T. M. Lowry said that the cold-working of metals was not a simple process. As a dental student he had observed that when one annealed a filling its size diminished. The same effect could be observed with other metals, silver and gold, for example. In the case of gold, working decreased the specific gravity and then increased it. The changes of this class were all very small, but quite definite.

Dr. S. Smith referred to the same point as Dr. Lowry, and thought that both authors had made very brief reference to the question of specific gravity. Mr. Alkins, in his paper, had said that in drawing-down his copper bolt the density became constant at 8·889, and Professor Edwards at the last meeting had said he had not got the change in density after hammering, which Alkins had found by cold-drawing. There was a great deal to be done in connection with the density of metals. For instance, he had recently wanted the density of a 70 : 30 brass, and had had difficulty in finding it.

Dr. W. H. Hatfield particularly appreciated the papers for their bearing on the amorphous theory. He had not altogether accepted the theory, but all the same he constantly used it. He thought Mr. Ellis's theory of re-crystallisation after an amorphous state was an excellent extension of the theory. If you converted a crystal to liquid, there was the latent heat of fusion set free, and we knew that in cold-working large quantities of heat were produced. The possible connection

here appeared worth following up. Referring to Sir Thomas Rose's example of the heavy and light pinches, he would like to know if either Sir Thomas or one of the authors had ever tried to divide the energy up under its proper heads—so much lost in the machine, so much spent in deformation, so much spent in modifying structure, &c.

This concluded the discussion, and as the time for adjournment had arrived, the President asked the authors to reply in writing in the Journal. The meeting then adjourned until the evening.

SCIENCE AND INDUSTRY.

The evening meeting opened at 8 o'clock when, three papers dealing with science and industry and the work of shop laboratories were read and discussed together. The papers were "Science and Industry in Relation to Non-Ferrous Metals" by Dr. Walter Rosenhain, "The Relationship between the Laboratory and the Workshop," by Mr. W. R. Barclay, and "The Scope of the Works Laboratory," by Mr. F. C. A. H. Lantsberry. The papers were read in abstract by their authors. We reprinted Dr. Rosenhain's paper last week, and reprint the other two in this issue.

Sir Gerard Muntz, Bart., opened the discussion. He said it had been suggested that Dr. Rosenhain's paper was very like his (the speaker's) presidential address of years ago. Those days seemed very remote, one hardly spoke the same language now-a-days. The demarkation line between scientific workers and shop people had now almost disappeared. The scientist had lost some of his purity, and had applied some of his knowledge, and the manufacturer had arrived at the conclusion that science was necessary. After all, science was only knowledge. It was practically impossible to discuss the papers properly. He might, however, mention a few points. Dr. Rosenhain had referred to the danger of the practical man trying to guide the direction of research. In his (the speaker's) opinion, this was not possible. If the practical man wanted something, he could only use what was already known in finding it. If you started a general research you usually found something quite different from what you set out to look for. After all, most great discoveries have been made by accident. He objected, however, to the idea that the manufacturer might not use science for a special research. The more of this that was done the better. Referring to Mr. Lantsberry's paper, Sir Gerard said that, in his opinion, the shop workman was a scientist. His language was not the language of the laboratory, but he had the knowledge. Often he knew quite as much as the scientist. You could never properly combine the workman, the manufacturer and the scientist, until you got the workman to believe in the scientist. The casual style of some young scientific workers was no use in the shops. The workman would never tell you what he knew if he was treated superciliously. To get good results the manufacturer must be behind the scientists, heart and soul. The status of the works chemist must be good, and must be sustained. It was still necessary to begin at the top and educate the chiefs to the advantages of science.

Mr. F. Tomlinson wished to say, as a manufacturer, that he agreed with all Dr. Rosenhain's ideas. He would like to emphasise Sir Gerard Muntz's point about the relation between scientific workers and the workman. In the firm with which he was connected, the shops had for the last 30 years looked upon the laboratory as the most important part of the organisation. The workmen referred to the laboratory chief as "The Doctor," and thoroughly believed in him and worked hand in hand with him. He knew if one of the younger assistants in the laboratory was referred to as the "Young Doctor" all was well, but if he was spoken of as "a young fellow from the laboratory," it was at once clear that he was not treating the workman as they had a right to be treated. He would like to refer to one of Dr. Rosenhain's points in connection with a Research Association. Such an association had practically been launched that day. They had had arguments with the Government Department concerned, but had got their own way and the freedom they wanted. He trusted that when they appointed a director of research they would be able to give him proper freedom of action.

Dr. W. H. Hatfield said there was a few points arising out of the papers he would like to bring up. We were all of us, and the nation also, interested in the application of science to industry. He thought the subject could almost look after itself. It payed. He knew of no single firm which had engaged competent scientific people which had not reaped more than it had spent. In Sheffield there were from three to four hundred highly-trained adult scientific workers—more than in any other city in the world, and the prosperity of Sheffield showed that applied science payed. What was wanted now was more science to apply. When one considered the money which in America and Germany was granted to the universities for research by Governments and individuals, it made similar grants in this country look very small. It was true that the Government had now granted 1,000,000*l.* he thought it was, for research, but in view of our great Empire, this was still far too small. If the State would look after the National Physical Laboratory and the Universities properly there would be plenty of applied science. The efficiency of human life was very low at present, he understood about 5 per cent. to 10 per cent., even when you considered laws we thoroughly understood, leaving out those we knew nothing of. It seemed a shame to take coal out of the earth and only turn 11 per cent. of it into useful work. Manufacturers, as a class, had all this balance of inefficiency to work at. The most practical steps to improve matters were to reinforce the Universities. They each wanted enough money to set up at least five or six research fellowships. There was enough work on physical constants alone to occupy a University for several years. In conclusion, he would refer to a point in Mr. Barclay's paper, where he spoke of a works laboratory not exercising its proper influence. In cases where this was so, its laboratory chief was to blame. It meant that the wrong man was in charge.

Mr. E. F. Law said that it was often possible to miss the point of a research, and he was not sure that both Mr. Barclay and Mr. Lantsberry had not done so. In reading their papers they had both said they would like to re-write them, one wanted to cut out the human touch, and the other the humour. But these were really the whole thing. A sense of humour and of humanity in the works management were the main considerations ensuring a proper relation between the laboratory and the workman in a factory.

Dr. J. H. Andrew said the question reduced itself to one of the scientific man and the practical man. He thought of the two the practical man was chiefly to blame for the non-advance of scientific practice. The practical man too often tried to squash the scientific man, and refused to listen to him. Mr. Lantsberry said the way out was for the scientific man to feed the practical man with sugar. But why should this be? The better way would be for the purely practical man to be eliminated altogether. If it were possible, the right procedure would be to put a scientifically-trained man at the head of every department. All men should have the same training. They would sort themselves out afterwards into research men and manufacturing men. He thought that in all large works there should be two laboratories—one for research and one for routine tests. He did not agree with Dr. Rosenhain's idea of one large central laboratory. He thought it would be much better to have a number of centres. Competition was a healthy thing even in the scientific world. He quite agreed that the scientific worker should have his status raised, and to do this we must make it worth a man's while to set out to be a scientific worker and to remain one.

Mr. F. S. J. Pile apologised for being merely a practical man, but he had had the misfortune to get a practical training. He thought we had got hold of the wrong end of the stick. Industry did not want science applied to it. Science was an end in itself, and the scientific worker was one of the industrial workers the same as anyone else. There was no reason why we should be opposed to industry. He was part of industry. The speaker was reminded of a time when he was testing a number of boys for colour-blindness. He came across one case in which at first he thought the boy was colour-blind, but later found out that what was the matter was that the boy merely did not know the names of the colours. It was the same in the workshop. The worker did not know the scientific language—he, for instance, knew nothing of the amorphous theory, but all the same he could do things that the so-called scientific workers could not. He was a scientific man. If you got on the right side of him he would tell you anything; there would be no difficulty about co-operation if you treated him properly. And if you let him see and understand what you were working at, he would have an enormous respect for you.

Professor T. Turner thought Dr. Rosenhain's paper a very comprehensive and thoughtful review of the position. Looking at the subject broadly, we had scientific workers and unscientific workers, and he agreed with Dr. Hatfield that even before more applied science we wanted more science—more scientific workers—more support for our Universities. Workers were a serious matter, and teachers looked with dismay on the losses of good men owing to the war. The supply was too small for the field. It was important that scientific students should, after a certain stage, be given a free hand. They should be allowed to go as far in pure science as they cared. Usually it was not long before they wished to go into industrial work. One scientist for whom he had little respect had said, at the Jubilee of the Chemical Society in that room, that he had worked out a series of compounds some years before, and was glad to say that so far they had had absolutely no practical application. This was what was called science for science's sake, which usually meant the pleasure of the worker for his own sake. He preferred work which was of some use to one's fellows; work with some spur behind it. Speaking of the work of shop people and workmen, it must be remembered that unscientific workers often had much knowledge. Often their so-called unscientific language was merely the scientific language of 100 or 200 years ago. When a puddler spoke of sulphur burning on the surface of the metal, he only used the term that a scientific man would have used 100 years ago. He had found workmen most anxious to learn the science of their own business. Obviously there should be close co-operation between the works laboratory and the shops. There was no use in having a tool if you did not use it properly. He agreed that large concerns should have two laboratories, one for research and one for routine tests, but one must not expect results too rapidly from research laboratories. The matter of two laboratories was, of course, difficult for a small firm, but the Research Association should be of value in such cases.

Mr. H. H. A. Greer rose merely to remind the meeting that it was precisely to foster closer co-operation between scientific workers and foremen and other shop workers that the Local Sections of the Institute had been formed.

Dr. Walter Rosenhain was the first of the authors to reply to the discussion. He said many speakers had referred to the knowledge possessed by practical workmen, but as a matter of fact, in writing his paper, he had not been thinking about the actual workman. He had been thinking of the heads of firms, and his object was to make a beginning As far as the practical workman was concerned, he had found that he possessed skill and usually some specialised knowledge, but as a rule he did not possess any general knowledge. If the terms of his problem were modified, he could not deal with it. Certainly we must educate at the bottom as well as at the top. All schools should give some fundamental scientific knowledge—public schools and all—so that it could not be possible, as it was at present, for a well educated person to be totally ignorant of science and the scientific method. The idea of separate laboratories for routine work and for research, he sympathised with. If possible, the research laboratory should be geographically separated from the routine laboratory. The idea

H.M. SEAPLANE-CARRYING SHIP "ARGUS"; BOILER UPTAKES AND HORIZONTAL FUNNELS.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

Fig. 23.

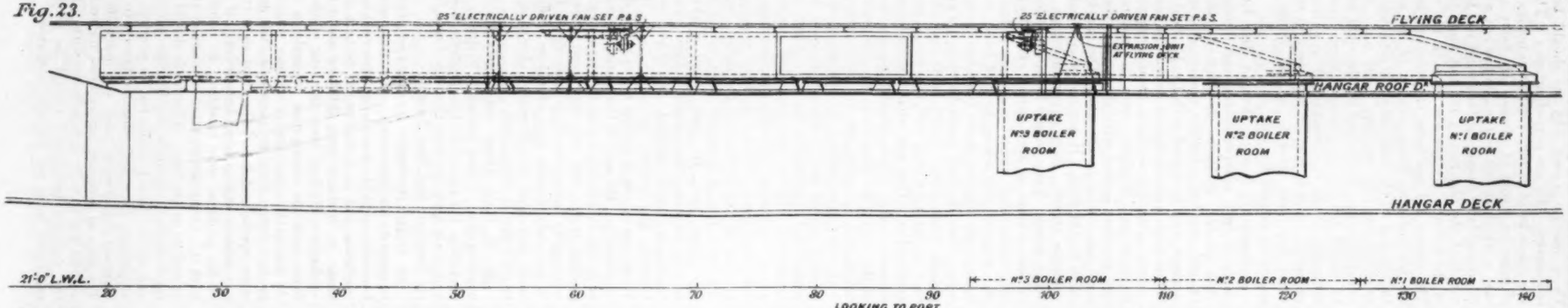
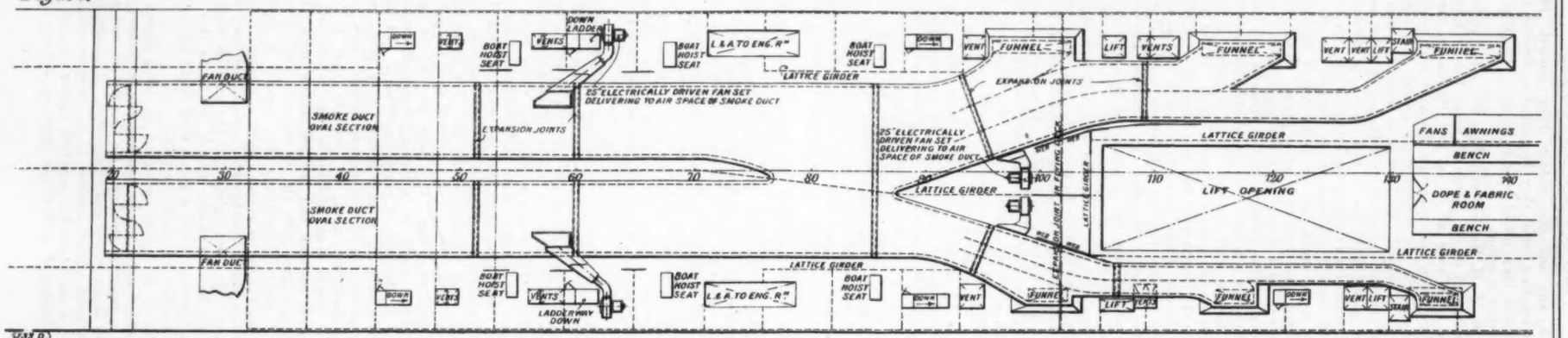

25" ELECTRICALLY DRIVEN FAN SET P & S.
25" ELECTRICALLY DRIVEN FAN SET P & S.
FLYING DECK
EXPANSION JOINT AT FLYING DECK
HANGAR ROOF D.
UPTAKE N°3 BOILER ROOM
UPTAKE N°2 BOILER ROOM
UPTAKE N°1 BOILER ROOM
HANGAR DECK
21'-0" L.W.L.
20 30 40 50 60 70 80 90 100 110 120 130 140
N°3 BOILER ROOM
N°2 BOILER ROOM
N°1 BOILER ROOM
LOOKING TO PORT

Fig. 24.



of research fellowships at the Universities was excellent, but even more was wanted. Professor Turner had spoken of the shortage of students. That shortage would continue until the rewards for scientific work were greater. Rewards were necessary, not only for invention, but also for discovery. Discoveries could not be patented, and there should be adequate rewards for pioneer work. The scientific career must be made attractive.

Mr. Barclay, replying very briefly, said that he had great sympathy with Dr. Hatfield's plea for the greater encouragement of University work, and agreed that the purely practical man should be eliminated.

Mr. Lantsberry, closing the discussion, said that too much must not be asked of the works laboratory manager. The works management must assist him. All metallurgical workers should have a good all-round scientific training. As more scientific training was got into business, its outlook would become broader.

The meeting then closed with a vote of thanks to the Chemical Society for the use of their room, proposed by the President, and seconded by Sir Gerard Muntz. It was announced that Professor Soddy would deliver the May lecture in the Caxton Hall on May 19, at 8 o'clock p.m.

H.M. SEAPLANE-CARRYING SHIP "ARGUS."

(*Concluded from page* 402.)

As promised in our previous article, we now reproduce drawings illustrating the arrangement of uptakes and horizontal funnels to ensure an uninterrupted flying deck. This is the principal novelty in the machinery, as the ship is propelled by a set of Parsons' turbines arranged in series on four shafts comprising one high-pressure, one intermediate-pressure and two low-pressure turbines, with an astern turbine incorporated in the aft end of each low-pressure ahead turbine. Steam is generated in six double-ended and six single-ended boilers, the latter being in the centre of the stokehold, as shown in the longitudinal section of the boiler room in Fig. 18, on Plate XXVIII. The boilers are worked under Howdens' forced draught system, and with the Wallsend-Howden oil fuel-burning installation. The total shaft horse-power was about 20,500 on trial, and this gives the ship a speed of 20¾ knots.

In our previous article we referred to the test made at the National Physical Laboratory at Teddington, which suggested the advantage, so far as flying was concerned, of the absence of funnels in their usual place, and the staff at Messrs. Beardmore's, on this advantage being established, at once

General Notes.		Average Revolutions of 81-in. Diameter Forced-Draught Fans.
Temperature of air entering fans at forward end of No. 1 boiler room	145 deg. F.	
Temperature of air entering furnaces at forward end of No. 1 boiler room	250 deg. F.	
Air pressure in fan discharge pipe	2 7/8-in. Water Gauge.	342
Air pressure in trunk leaving air heater — Forward end No. 1 boiler room	1¼-in. Water Gauge.	
Air pressure at furnace	1¼-in. Water Gauge.	
Air pressure in fan discharge pipe	2 7/8-in. Water Gauge.	318
Air pressure in trunk leaving air heater — No. 2 boiler room	1¼-in. Water Gauge.	
Air pressure at furnace	1¼-in. Water Gauge.	
Temperature of air entering fans at aft end of No. 3 boiler room	120 deg. F.	
Temperature of air entering furnaces at aft end of No. 3 boiler room	230 deg. F.	
Air pressure in fan discharge pipe	2 7/8-in. Water Gauge.	278
Air pressure in trunk leaving air heater — Aft end No. 3 boiler room	1¼-in. Water Gauge.	
Air pressure at furnace	1¼-in. Water Gauge.	

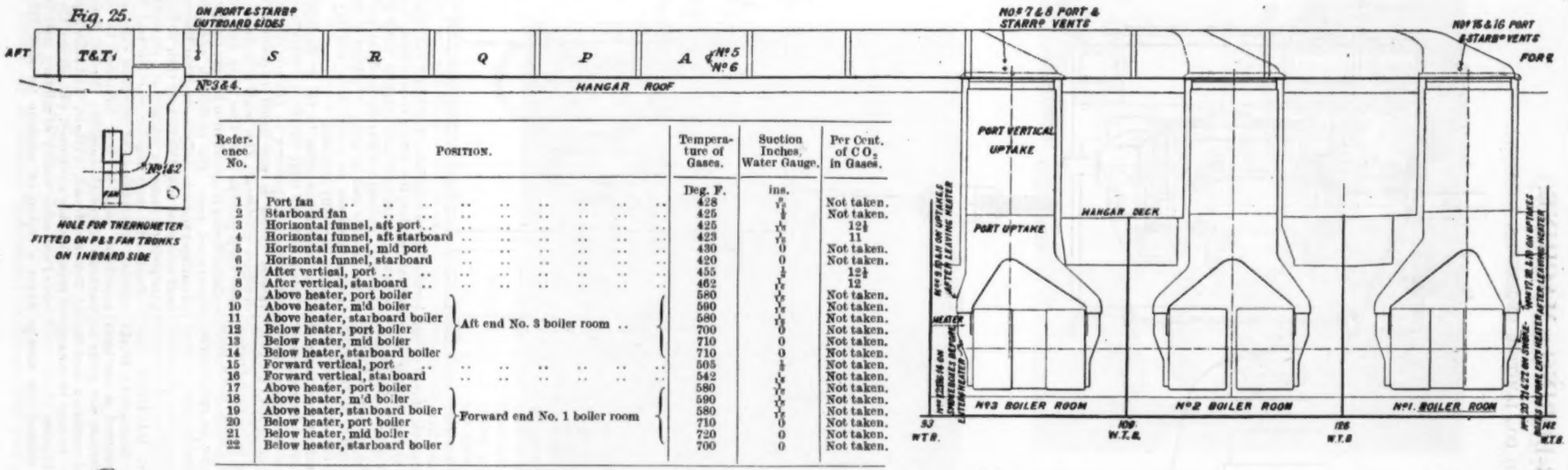
117 inch Diameter Induced Draught Fans.

	Revolutions.	Amperes.	Volts.
Port Fan	214	111	220
Starboard Fan	213	117	220

H.M. SEAPLANE-CARRYING SHIP "ARGUS"; BOILER UPTAKES AND HORIZONTAL FUNNELS.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

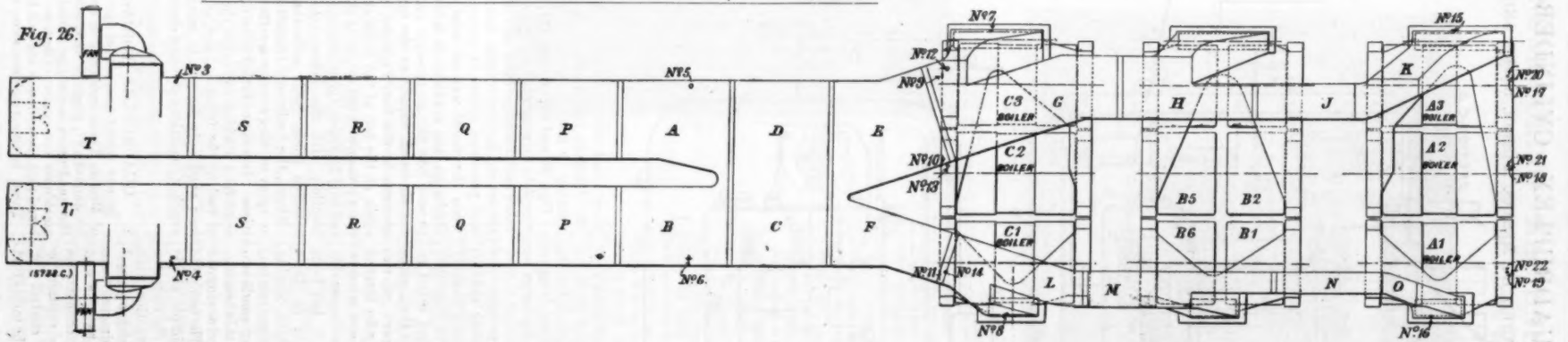
Fig. 25.



Reference No.	Position.	Temperature of Gases.	Suction Inches Water Gauge.	Per Cent. of CO_2 in Gases.
		Deg. F.	ins.	
1	Port fan	428	½	Not taken.
2	Starboard fan	425	½	Not taken.
3	Horizontal funnel, aft port	425	½	12½
4	Horizontal funnel, aft starboard	423	½	11
5	Horizontal funnel, mid port	430	0	Not taken.
6	Horizontal funnel, starboard	420	0	Not taken.
7	After vertical, port	455	½	12½
8	After vertical, starboard	462	½	12
9	Above heater, port boiler	580	½	Not taken.
10	Above heater, mid boiler	590	½	Not taken.
11	Above heater, starboard boiler	580	½	Not taken.
12	Below heater, port boiler	700	0	Not taken.
13	Below heater, mid boiler	710	0	Not taken.
14	Below heater, starboard boiler	710	0	Not taken.
15	Forward vertical, port	505	½	Not taken.
16	Forward vertical, starboard	542	½	Not taken.
17	Above heater, port boiler	580	½	Not taken.
18	Above heater, m'd boiler	590	½	Not taken.
19	Above heater, starboard boiler	580	½	Not taken.
20	Below heater, port boiler	710	0	Not taken.
21	Below heater, mid boiler	720	0	Not taken.
22	Below heater, starboard boiler	700	0	Not taken.

(Aft end No. 3 boiler room: Nos. 9–14)
(Forward end No. 1 boiler room: Nos. 17–22)

Fig. 26.



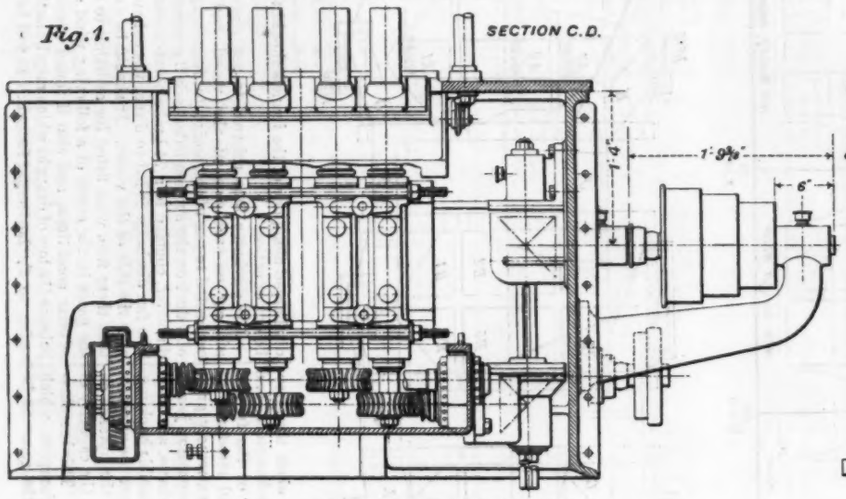
set about the task of devising details for substituting for the central uptakes vertical side uptakes and a horizontal funnel to discharge the gases astern of the ship. The side uptakes are not novel, but the horizontal funnels are unique. The details we publish of the uptakes, on Plate XXVIII, and of the horizontal funnels, on the opposite page, will be studied with interest, particularly as they proved completely successful. After only three days' trial, during which all main and auxiliary machinery was thoroughly tested, the vessel proceeded to her allotted station, without any modifications or additions to her funnels or other parts of the machinery.

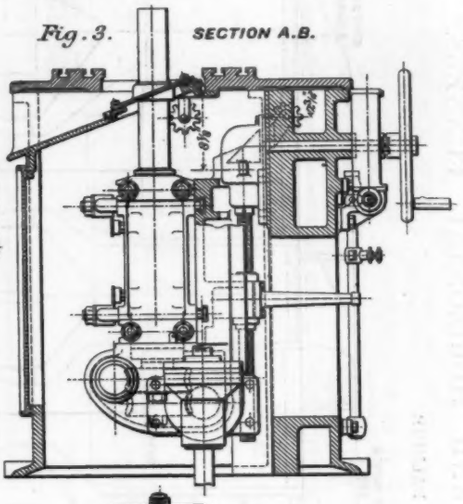
There is nothing remarkable about the uptakes from the boilers up to the hangar-roof deck, except that the uptakes are led to the sides of the vessel instead of the centre. As shown in Figs. 23 and 24, on page 430, the uptakes then join into two lines of horizontal funnels running right aft, and discharging the gases at the stern of the vessel. The same section and plan also show the electric fans fitted for supplying cold air to the funnel casing. These fans were introduced to assist in keeping a comparatively low temperature underneath the flying deck, as it was feared owing to the top of the funnel being so close to this deck, that in warm weather the deck would become unduly heated. The horizontal funnels immediately abaft the aftermost uptake are united by a breeches-piece, and from thence right aft the corners of the funnels are rounded off to reduce the wind resistance as much as possible. Owing to the extremely great length of the funnels, a number of expansion joints, specially designed to ensure gas tightness, are fitted in convenient positions, to prevent possible buckling. The breeches-piece was fitted to balance the quantity of gases being discharged owing to the uptakes on one side of the vessel having double the capacity of those on the other side (see Fig. 20). This breeches-piece is also fitted with suitable dampers, which serve the purpose of enabling all the gases to be discharged along one of the funnels should the other be out of action.

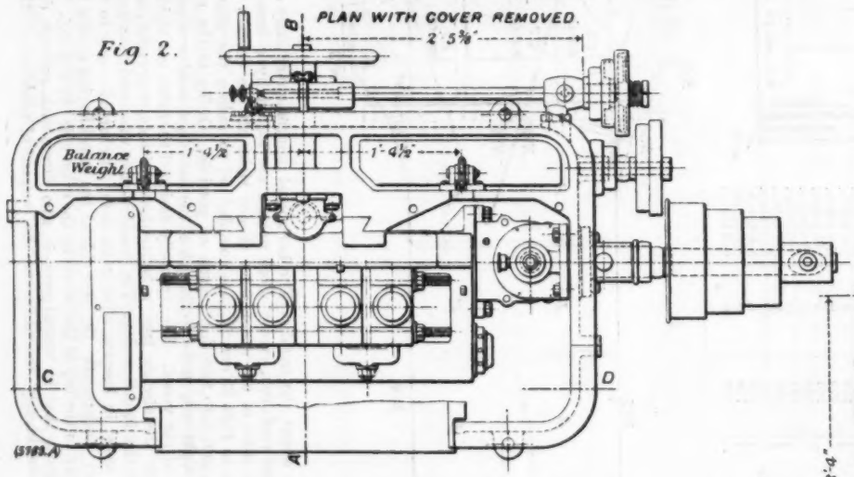
The discharge fans referred to are placed right aft, one on each side of the vessel, and each is connected to one of the horizontal funnels by means of a duct on the suction side, each fan being 117 in. diameter, coupled to a 74 brake horse-power motor. The fan discharge is led to direct the exhaust gases over the side of the vessel. It should be explained that these fans were fitted for assisting to exhaust the gases in the event of a following wind or other adverse conditions, and also if found necessary to balance the loss of draught which may be anticipated owing to the horizontal funnels. It will be readily

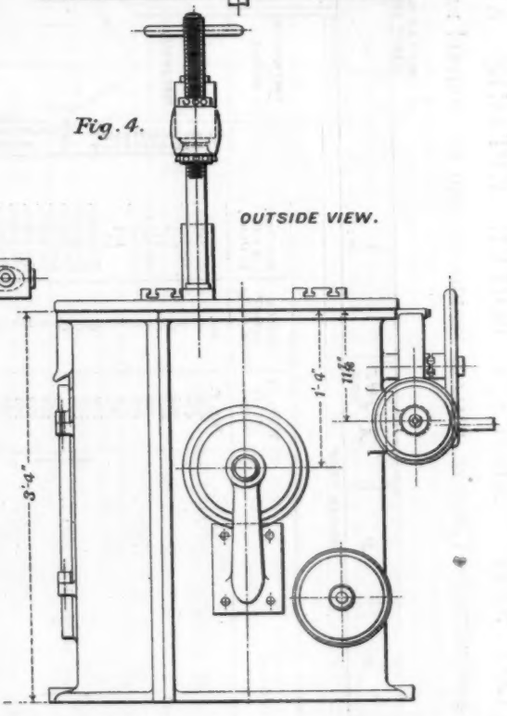
QUADRUPLEX CYLINDER-BORING MACHINE.

CONSTRUCTED BY MESSRS. MASSON, SCOTT, AND CO., LIMITED, ENGINEERS, LONDON.









understood that the fitting of these fans somewhat complicated the arrangement, as it was necessary to have suitable dampers in the funnels aft of the fan to prevent short circuiting, and similar dampers were, of course, necessary in the fan discharge for the same reason.

It was, of course, important to prevent any possibility of both sets of dampers being shut at one time, or *vice versa*, and thereby causing possibly serious trouble in the stokehold. An ingenious device was eventually decided upon and fitted to the damper control gear which ensured that, without any further attention on the part of the operator, the motor of a fan can only be started when the dampers are in their correct relative positions, and which also renders it impossible for the motor to be stopped, once it has been started, until the dampers are again in their correct relative positions. The fan-shaft bearing next to the fan is of specially heavy construction, and to ensure proper service in working condition, a water service arrangement is fitted to this bearing, the water being also automatically started or stopped when the motor is started or stopped. The complete control gear is connected up to a simple single control for each fan, and the action of the operator consists in turning a handle. In conjunction with this control gear, a special design of telegraph and indicator was fitted by Messrs. Beardmore, from the bridge to the control station of the fans and dampers at the aft end of the vessel, with connections to the engine-room, thus enabling the captain or the engineer officer of the vessel to control the position of the dampers at any time. The indicators show at all times the exact position of the dampers, and whether the fans are running or not.

Figs. 25 and 26, on page 431, show the complete arrangement of the funnels, uptakes and discharge fans, and with these are set out in tabular form, temperatures and pressures taken at various points when the vessel was on trial with the discharge fans working. It is interesting to note how the air pressure varies from the air trunk supply to the furnaces, down to no pressure in the lower uptake, and gradually rises again at the top of the vertical uptake, falls again to no pressure at the centre of the horizontal funnel, and only increases again just forward of the fan trunk junction with the horizontal funnel. After exhaustive trials, both with the fans working and without, the horizontal funnels proved satisfactory, in spite of the stormy weather prevailing during trials It was not found to be necessary to have the large fans working to ensure the proper combustion of fuel in the furnaces, and as stated, these large fans need only be put in service to suit varying weather conditions if found desirable.

QUADRUPLEX BORING MACHINE.

In our recent account of the Basingstoke Works of Messrs. Thornycroft which appeared in our issue for January 17, page 76 *ante*, reference was made to the quadruplex undertype boring machines used for machining the engine cylinders. It may be remembered that the cylinders are cast in pairs.

These boring machines were unusual not merely because the casting being machined was clamped in its normal position, the boring spindle being driven from beneath, but because each machine itself was of low visibility; although it was obviously at work nothing of its activity was in sight. Perhaps a better comparison is to use an engine term and say that the machine is totally enclosed.

The original machines in use at Basingstoke were French, but the large extension necessitated by the war made it imperative to procure others. Due to various causes it was found impossible to obtain duplicate machines. This made it necessary either to alter shop practice and thus have two methods of cylinder boring in operation or to have similar machines constructed here. The method in vogue had many advantages and it is easily realised that Messrs. Thornycroft were most unwilling to vary their methods, which were giving a first-rate product at a reasonable cost.

Practically every regular machine tool firm were confined to standardised machines, and could not undertake, were in fact forbidden to undertake, machines of special character. Messrs. Masson Scott, of Townmead-road, Fulham, well-known as makers of paper-making machinery, who, during the war, had turned out some variety of military material, among others a cutting-off machine for shell billets, were

QUADRUPLEX CYLINDER-BORING MACHINE.

CONSTRUCTED BY MESSRS. MASSON, SCOTT, AND CO., LIMITED, ENGINEERS, LONDON.

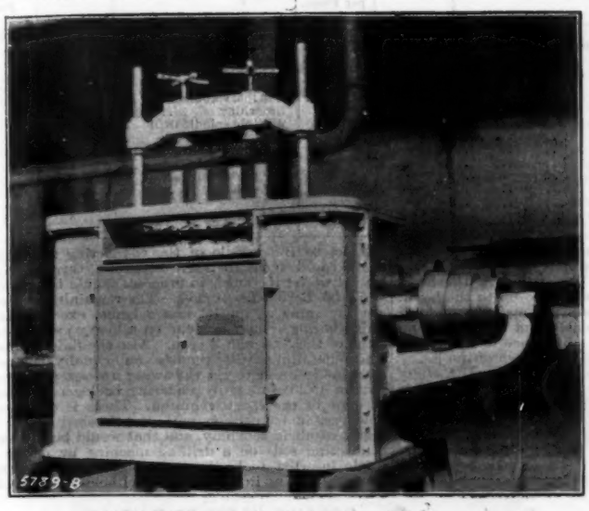


Fig. 5.

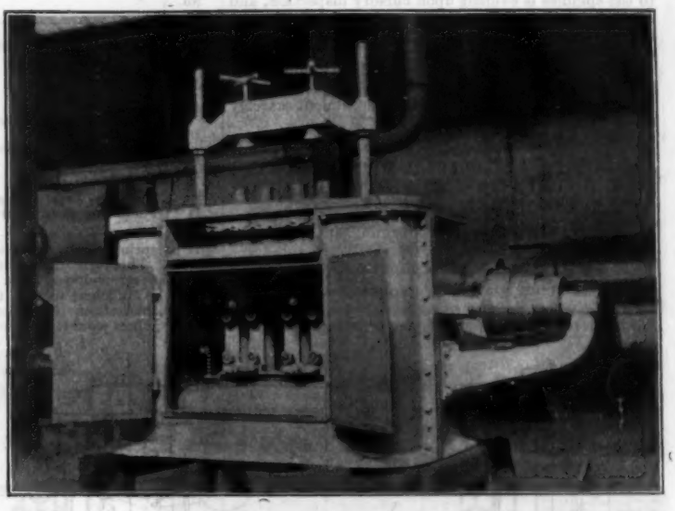


Fig. 6.

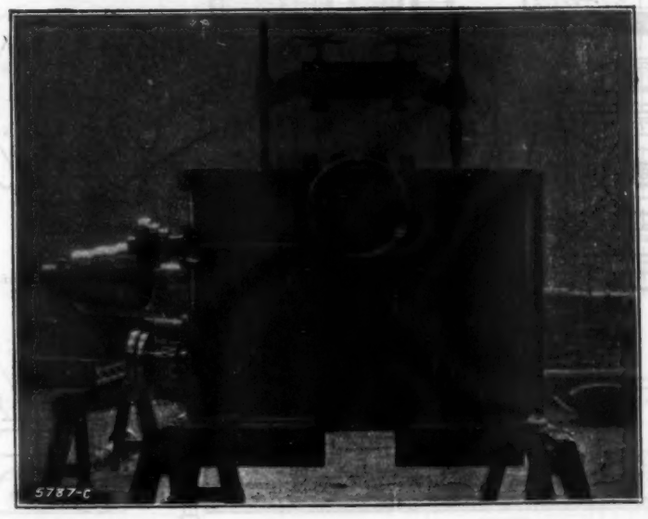


Fig. 7.

asked to construct a machine on the French model. Due to this fact and with the co-operation and courtesy of both firms involved, we are in a position to illustrate and describe in detail the machine in question. It is very creditable to be able to state that the commission was executed to the entire satisfaction of so discriminating a firm as Thornycrofts, who consider the Masson-Scott machine superior in certain respects to the original model. Machine-tool making found some strange quarters during the war period, and that work incorporating advances in design with the exactitude necessary to machine tools should have been carried out in a paper-making machinery shop, shows once more the ingenuity and adaptability of the all-round type of shop. The usual run of work at Fulham is of very varied and highly skilled character, but it did not include the making of machine tools.

The line illustrations on page 432, and the photographs reproduced on the present page, show clearly the construction of the machine. The main casting is in two halves and is approximately a rectangular box with a separate top entablature, which is provided with the usual slots for bolt heads. On this entablature a fixture to suit the special type of cylinder is mounted. Incorporated with the main casting is an angle chute, into which the chips fall and gain egress from the machine. Large hinged doors give access to the internal mechanism.

The main drive is by an external three-stepped pulley, from the spindle of which the feed spindle is, driven by belt.

Integral with the main casting, inside the machine is a vertical dovetail slide, and upon this a carriage is mounted arranged to rise and fall.

The main horizontal drive is by means of a pair of bevel wheels (again inside the machine) transferred to a vertical splined shaft, which again, by sliding bevel wheels, translates its motion to a pair of horizontal worm spindles interconnected by single helical wheels at the reverse end. The worms are continuous throughout their length, and thrust is cared for by ball bearings. Reference to the sectional illustration will show that two worm wheels engage with the one worm running right hand, and two engage with the other which runs left hand. As this engagement is upon reverse sides, the whole of the four wheels run in the one direction.

To close pitch the centre lines of the boring spindles to which the worm wheels are keyed, the wheels are at different levels, as also are the worms (or rather lead screws).

The whole of this lower gearing actuating the vertical boring spindles is framed in a traylike termination to the casting, which forms the carriage. This allows the phosphor-bronze wheels and hardened and ground lead screws to run in an oil bath.

Each spindle and bearing is a separate component, removable singly, and assembled by distance pieces and longitudinal bolts giving parallel adjustment and centre distance pitch. The spindles are also cramped in pairs to the main carriage at right angles.

Such a construction allows variations to be made in centre distances of the spindles, as it is only necessary to substitute fresh distance pieces between the spindles of each component. One spindle alone is located positively to the carriage, the remainder have their positions determined from this as a pilot.

As shown, the spindles are paired, since the Thornycroft engine consists of a pair of twin castings, and two of these are mounted at the one time for machining.

Advantage is taken of the space behind the slide face upon which the carriage travels, to locate a pair of balance weights, which are connected by sprocket chain to the carriage.

The vertical boring spindles are supported throughout their entire length, and both spindle and bearing are ground to very fine limits. A marked feature of the Masson-Scott machine is the precision with which the spindles are guided, in this particular as well as others it is an improvement over its French prototype. Feed is given by belt drive from main spindle on to an intermediate spindle and a second belt drives an external feed spindle, giving self action by means of a worm and worm wheel. A hand wheel engaged by toothed clutch is also provided. Motion is transmitted through bevel gearing to actuate the vertical feed screw in the gap of carriage.

As it is impossible in use to determine the height of spindle relative to the work, an automatic knock-off to the feed is essential. An arm which projects from carriage through a slot on the hand-wheel side of the machine, engages a stop on a vertical exterior spindle; this by slight upward motion and the spring at the reverse end of the feed spindle throws the feed out of engagement at any point determined by the position of the stop.

Integral with the top entablature and supported by threaded pillars adjustable for height is a bridge clamp to hold the cylinder castings against the upward thrust of the tool.

The machine is not strictly special to one job and so unadaptable for a variety of work. It is designed obviously for motor car engine cylinders, but is not confined to a particular type engine. The four spindles can be set equi-distant for monoblock castings or given an extended centre distance; they can also be used for single cylinders. Any type of fixture may be used on the slotted entablature for any type of cylinder.

The machine is unusual in more than one particular. The reversal of direction in which the machining is performed, the ingenious manner in which, by distance pieces and separate component spindles, variation can be made, the total enclosure of all mechanism, the relatively large amount of gearing employed, the compact arrangement of the mechanism itself, the very perfect lubricating arrangements, all call for notice. Worm gearing, by its deliberate motion and constant torque, is ideal for boring operations, while the natural removal of chips by gravity allows free cutting, with none of the attendant troubles incident to horizontal boring. The machine finish obtained at Basingstoke upon the

bores of the cylinders, minimises the amount of grinding to be done subsequently upon the Heald internal grinders employed.

The rigidity which is essential to circularity and truth in a boring operation is amply secured by the construction of the machine, the very long bearing to the spindles is evident upon cursory inspection, and apart from the oil bath to the worm drive gearing, full provision is made for lubrication throughout the machine. The photographs and line illustration should, together with the foregoing description, make the machine and its construction clear, inspection of the machine itself by reason of its concealment scarcely allows all its features to be realised.

JIGS, TOOLS, AND SPECIAL MACHINES, WITH THEIR RELATION TO THE PRODUCTION OF STANDARDISED PARTS.*

By HERBERT C. ARMITAGE, of Birmingham, Associate Member.

(*Concluded from page* 406.)

SCHEME FOR LARGE PRODUCTION.

THE jigs which are now to be described have for their object the production of an average of 20 rods per hour

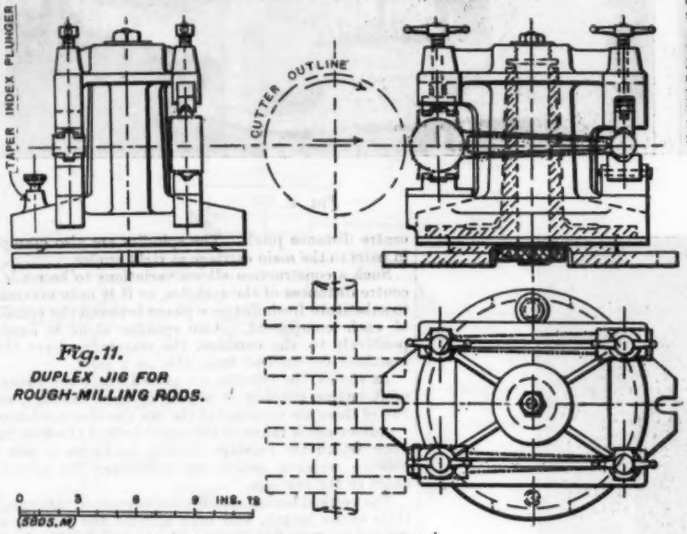


Fig. 11.
DUPLEX JIG FOR ROUGH-MILLING RODS.

and will represent in their construction the nearest it is possible to get to continuous cutting without the aid of special machines, and using standard machine tools. The lay-out is shown in Table IV, and scarcely differs in the order of operations from the first one.

Mill Both Ends of Connecting Rod (Fig. 11).—There are four cutters used with this jig, and it should be noticed that the method applies whether the small boss of the connecting-rod is wider or narrower than the large end. The cutters are fed up to the rods in the same way as in the jig described in the smaller scheme, and after having taken the cut, it is indexed round through 180 deg. The general disadvantages of jigs of this type is that very exact workmanship is required, in order to achieve accurate results, as a small inaccuracy in their alignment is magnified in the work. Owing to the height of the work above the machine table, a special construction has been arranged to obtain the necessary stiffness. The base-plate is built up in the form of an internal taper-sleeve, inside the indexing portion, which takes the entire thrust of the cutters. Clamping in position is effected by means of a "tommy bar" in the base of the structure. Additional support is given by the annular slide strip which goes right round the revolving portion. To obtain the maximum production two jigs would be mounted upon the table of one machine, with the cutters in between the two jigs. It would mean alternate directions of feed for the table, and in one case the cutters would have to cut upwards; with the stiff construction shown, it should, however, be possible to obtain accurate work. One jig would be loaded whilst the cutters were at work on the opposite fixture, but it is questionable whether a jig of this type is preferable to three or four jigs which could split the operations up into their simplest parts. By doing this, there would be no approach to continuous cutting, but the actual time of operation would be very much reduced.

Drill Small End of Connecting Rod (Fig. 12).—This jig will drill four connecting rods at once, with the minimum of trouble in placing them in the tool. While they are being drilled on one side of it, four other connecting rods are being loaded on the other side. In some drilling machines it is possible to move the table lengthways to fixed stops, so that the screw and hand wheel which are here embodied in the jig will not then be necessary. It will be observed that the bushes are moved up and down in a very rigid guide by means of a long handle which will be sprung down against a latch at the end of the handle. This form of construction is better and quicker than the screw-down bush. The spring in the lever should be sufficient to hold the handle up to the latch. In the illustration, the holes are perhaps shown closer together than would be practicable, but this makes no difference to the essential design of the jig.

Drill Large End of Connecting Rod.—This jig is practically the same in design as the previous one, except that the connecting rods would be positioned from the small hole.

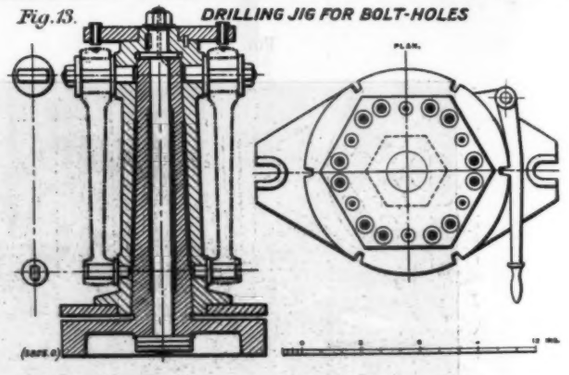


Fig. 13. *DRILLING JIG FOR BOLT-HOLES*

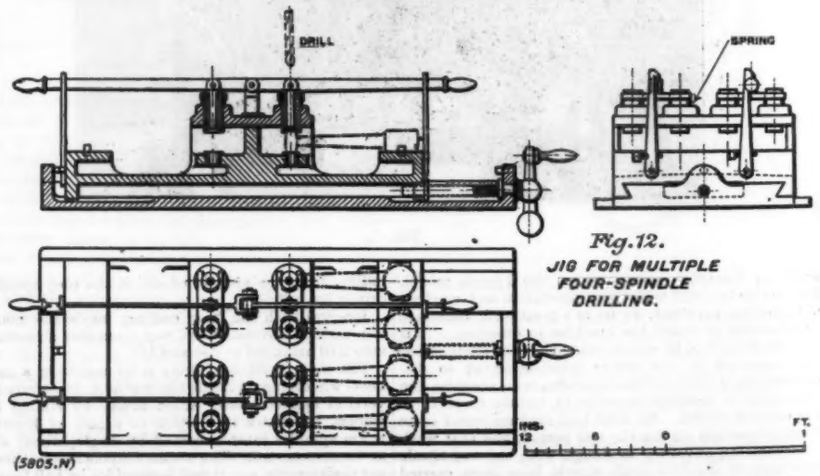


Fig. 12.
JIG FOR MULTIPLE FOUR-SPINDLE DRILLING.

These two last named jigs represent the nearest that can be obtained to continuous drilling without the aid of special machine tools, but each of them will keep one man per machine fully occupied in loading and unloading one jig.

Drill Bolt Holes and Centre End of Connecting Rod (Fig. 13, above).—This jig is intended for use in a multiple spindle drilling machine, and there should be at least four drilling spindles and two centreing spindles at work at once to effect any economy. The jig will be indexed round by hand, and the sleeve support construction is again worthy of note.

Mill Sides of Connecting Rod.—This operation will have to be done in practically the same manner as the one shown in the last scheme, but it is possible that economy might be effected by putting six or eight rods in a line, and running a facing cutter across them at the full width of the surface between the bosses. There would, however, be difficulties in giving an adequate support to the middle of the connecting rod, without complicated construction. Separate carriers to be loaded whilst the cut is in progress should be provided.

Finish Boring Large Hole.—The remaining operations are the same as in the first scheme, except that the finish boring should be done on a heavy gap bed-turret lathe of the "Gisholt" type. Also the finish boring for white-metalling will require an equally substantial machine in order to get the swing necessary, but would have a disadvantage in rendering back-gear useless, on account of the speed required. There is one method however, in connection with the finished boring that might result in economy, and that would be to bore the connecting rods on a drilling machine by means of a single inserted tool piloted boring bar, then changing the bar, putting in a recessing tool holder, and finishing off with a reamer. The accuracy of the finished boring is not of vital importance when the connecting rod has to be white metalled, and if the finish is slightly rough, it will make the white metal hold even better. The practice is not to be recommended if turret lathes are available.

TABLE IV.—SCHEME FOR LARGE PRODUCTION.
Output = 20 per hour = 1,000 per week.

Operation No.	Description of Operation.	Fig. No. of Jig.	Time Required, Minutes per Piece.	Type of Machine.	No. of Machines.	Labour Cost per Piece.
						d.
1	Heat treatment of stamping	—	—	—	—	—
2	File burrs, &c.	—	—	—	—	—
3	Mill both ends of rod	11	20	Horizontal miller	7	3·3
4	Drill small end	12	3	Multiple spindle drill	1	0·5
5	Drill large end	—	5	Multiple spindle drill	2	0·9
6	Broach small end	—	½	Broaching	1	0·1
7	Drill bolt holes and centre end of rod	13	5	Multiple spindle drill	2	0·9
8	Mill sides of rod	—	15	Vertical miller	5	2·5
9	Mill across top bolt holes	—	5	Horizontal miller	2	0·9
10	Mill sides of bolt faces	—	3	Horizontal miller	1	0·5
11	Part cap	—	5	Horizontal miller	2	0·9
12	Finish bore large end	—	20	Turret lathe	7	3·3
13	Run white metal in large end	—	—	—	—	—
14	Finish bore white metal in large end	—	10	Turret lathe	3	1·7

SCHEME FOR MAXIMUM PRODUCTION.

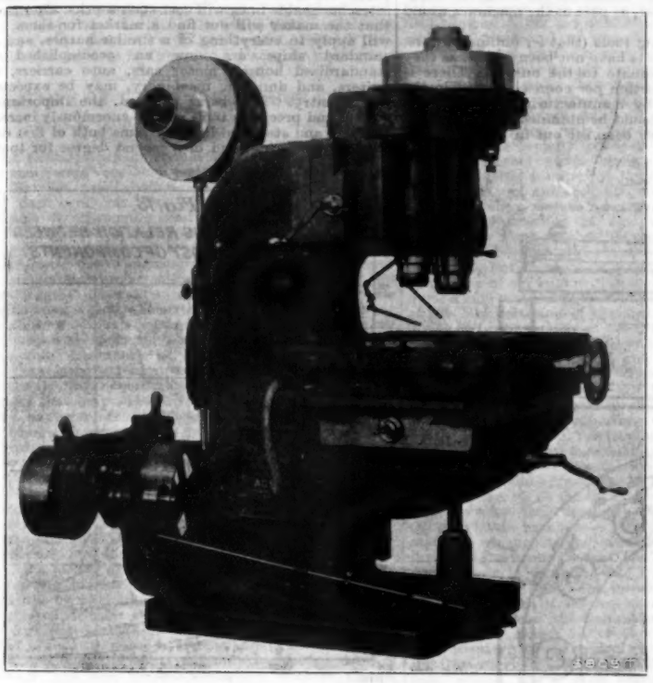
In this scheme it is proposed to investigate the possibilities of continuous cutting with special machine tools and the lay-out is given in Table V, page 436.

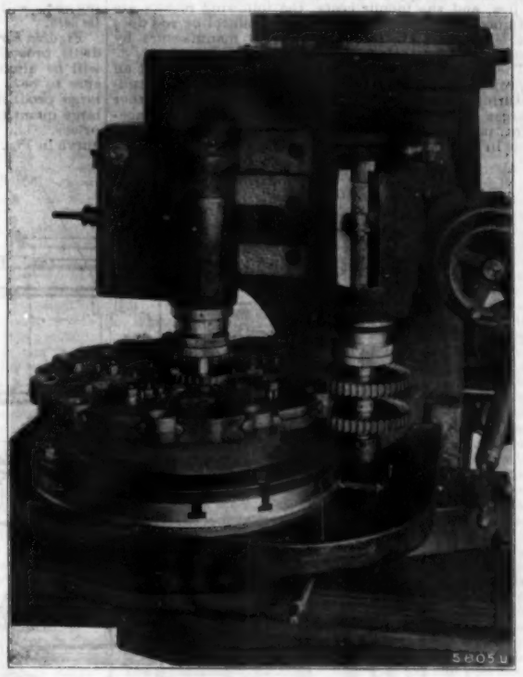
Mill Ends of Connecting Rod.—There are two vertical spindles, and the internal cutters will move in the smallest circle possible. The machine will not have to be stopped for loading, and there will be a continuous production from the machine. Unfortunately, when continuous cutting is adopted, there are several disadvantages, the principal one being that of getting the cutters to stand up effectively to the work. A machine of this

* Paper read before the Institution of Mechanical Engineers, Friday, March 21, 1919.

description is usually more powerful in strength and feed than can be reasonably expected from the cutters. Also since the best of cutters will become dull in four to five hours, there is a considerable waste of time in changing them, and several spare sets must be kept in readiness. Assuming that the machine tool turns out connecting rods at the rate of 60 per hour, and that there is a stoppage of work for 30 minutes at the very least, to change cutters, it means a loss of output of about 40 connecting rods during that time. Considering that this will take place twice a day, it makes a very serious drawback. There is usually a similar trouble experienced in holding the pieces in continuous milling, as in multiple-operation machines. In the engravings, on this page, there are shown illustrations of a Becker double spindle continuous miller set up on connecting rods, where the design of jig employed is decidedly ingenious. The Becker Company claim that they can mill up to 90 connecting rods per hour, but the output must depend mainly upon the degree to which the rods have been previously annealed and pickled to remove scale.

Continuous Drill Both Ends of Connecting Rod (Fig. 14).—This figure shows in outline a four-spindle drilling machine, and no pretence is made that the machine is proportioned correctly. Upon the table there are four pairs of connecting rods. The saddle feeds down to drill the holes, the cut is automatically released, then it traverses upwards quickly to clear the work. In the meantime, the table indexes round a quarter of a turn, and two more rods are brought into position for drilling. The saddle again feeds downwards, and by this cycle of operations, continuous drilling is very economically obtained. It should be quite possible for one man to mind two or even three machines of this type, and this is where the real economy of highly specialised machine tools comes in, otherwise there are few advantages worth mention. It is worth noting that a machine of this type can be used for any number of similar jobs, and should therefore not be any loss or even stand idle in a manufacturing works which has connecting rods of any description to make. It is very surprising indeed to notice that few of the larger type of machine tools automatically index the work into position. Possibly a really first-class and powerful index mechanism has to be designed, although the principle is fairly well established in automatic screw machines and gear cutters.





DOUBLE-SPINDLE CONTINUOUS MILLER (BECKER); GENERAL VIEW AND VIEW SHOWING THE MILLING OF 10½-IN. CONNECTING-RODS.

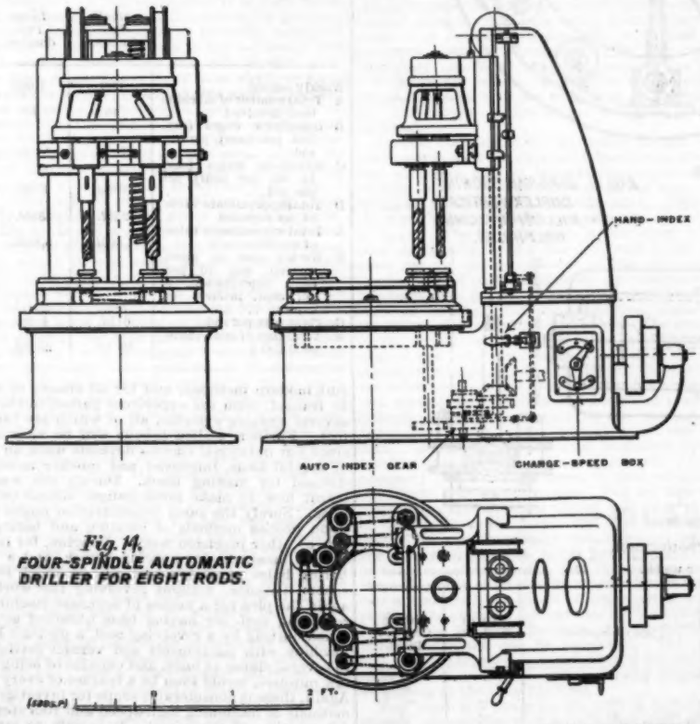


Fig. 14.
FOUR-SPINDLE AUTOMATIC DRILLER FOR EIGHT RODS.

Continuous Drill Bolt Holes and Centre Rods (Fig. 15).—This machine is practically identical in principle with the one previously described, except that the spindles are horizontal. The indexing will be for a larger number of rods, and the spindles, saddles, and index motion are driven by means of an electric motor. In practice it will be found very likely that another head can be placed upon the other side of the machine, thereby getting double the output. It would be necessary, however, to drive the drills in the saddle from the same motor.

Continuous Mill Sides of Rod (Fig. 16).—In this machine, of which a plan only is shown in the drawing, there are two substantial face-milling heads. The connecting rods are arranged radially on a circular frame, which is driven round at the correct feeding speed. The whole machine is driven by an electric motor, and the rods are loaded in on the opposite side of the machine whilst revolving. There is a doubtful economy, however, in continuous milling of this description, as the rods would have to be spaced some considerable distance apart. For instance, if the metal between them is only 1¼ in. and the rods themselves are ¾ in. wide, it means that a cut has to be taken over 2 in. in order to mill ¾ in. Supposing that the rate of feed is 1 in. per minute, it will be seen that the effective continuous milling feed obtained is only ¾ in. per minute. This is true of any continuous milling operation, and it is doubtful whether the application shown is worth the results obtained. In this machine some support would have to be given to the middle of the connecting rod to prevent excessive chattering. Compressed air operated clamps and jig stops will prove very useful in this respect, and will greatly reduce the time in fixing the work.

Milling Across Bolt Hole Bosses and Faces.—It is practically impossible to "continuous mill" across the top of the bolt holes, except by a profiling motion, and this will necessitate a complicated machine. For milling the sides of the bolt faces, a duplex vertical spindle milling machine would be very effective, and almost continuous milling action could be obtained with very little trouble. The diagram of this is shown in Fig. 17. It is strange why this type of machine is not more popular, as it undoubtedly has a very wide field of usefulness for any description of rods, or repetition work which requires milling at both ends.

Finish Boring on Special Machines.—There is little to be gained by building a special machine tool for finishing boring the large end, and up to the present date nothing better than the turret lathe has been found. So far as the author knows, there has been no effective method yet devised for obtaining accurate continuous

boring action, because this can only be obtained by revolving the tool. It is the universal practice to revolve the work where its size permits, and feed the tool. If it were possible to obtain accurate results by means of a revolving cutting tool, combined with a turret, continuous action would be easily obtainable.

COMPARATIVE RESULTS BETWEEN THE THREE SCHEMES.

By totalling up the machine tool values, expenditure in jigs, and the labour costs, the following results are obtained, in spite of the fact that a connecting rod does not lend itself exceptionally well to manufacture by special machine tools (see Table VI.).

The figures are somewhat startling, and show that an approximate trebling of production reduces the manufacturing cost in each case by about one-half. Other charges (which have not been shown), such as management, power, establishment, &c. will be practically the same in each case. By referring to the operation tables, it will be seen that in each scheme the same finishing methods are to be employed, namely, the turret lathe. Where, in the small production lay-out, two lathes are required, there will be 20 necessary to cope with the largest output. The great economy shown, therefore, will be tremendously accentuated if special finishing machines could be employed. Under each scheme a properly balanced plant has been assumed. If there is an output of less than the maximum per week, the working costs will be increased, as part of the machines would be idle.

Figures for the wearing tools (that is, milling cutters, drills, broaches, &c.), costs have not been added, as they will be almost proportionate to the output. There is sure to be a slight reduction per connecting rod in the large productions, for by manufacturing or buying in large quantities, they should be obtained at much lower prices. The figures have been set out in the form of a curve in Fig. 18.

Lines of Future Development.—In conclusion, a few notes must be added regarding the future developments of tools for interchangeable and repetition production. The war has only thoroughly awakened us to the huge possibilities of accurately working to standardised dimensions and given limits for component parts. It is doubtful (though possible) that, before the war, there was an English motor car built with absolutely interchangeable parts. It is a certainty that motor cars not built on interchangeable lines will cost such a price after the war that the maker will not find a market for them. This will apply to everything of a similar nature, and since standard ships are now an accomplished fact, standardised houses, motor cars, auto carriers, typewriters, and domestic machinery, may be expected in this country. This being granted, the importance of special and precision tools will be enormously increased. Reliable and standard limit systems both of first degree for manufacturing, and of a second degree for tools, to suit modern methods, and for all classes of work, must be framed, from the experience gained in the use of the several existing systems, all of which are far from perfect. Further, skilled labour will be very scarce, and since our industrial success depends upon an abundance of special tools, improved and quicker means must be devised for making them. During the war we have learnt how to make screw-gauges almost on repetition lines. Surely the same concentration might be exerted upon precise methods of locating and boring holes for jigs or other precision work. Imagine, for instance, an optical measuring or spacing device, and a method of boring holes to within half a thousandth limit in the centre distance, without revolving the work. This is again the plea for a means of accurate machining with a revolving tool, for having once obtained accurate precision cutting by a revolving tool, a jig-bush hole boring machine with micrometer and vernier settings to bore in several planes at once, and capable of being set up in a few minutes, would soon be a feature of every tool-room. Again, there is considerable scope for investigation in the methods of hardening high-speed and tool steels without deformation of the metal. It is safe to state that if steel-makers do not produce non-shrinking and non-warping steels, progress can only be obtained by greater perfection of the grinding machine and its wheels, and extending considerably the use of formed wheels.

One of the greatest manufacturing troubles now experienced on aero engine parts is in the nickel-steel case-hardened parts. Several heat treatments are usually necessary, and even then, after hardening, the component usually twists and distorts out of shape or

Fig. 15. CONTINUOUS DRILLING MACHINE FOR BOLT-HOLES.

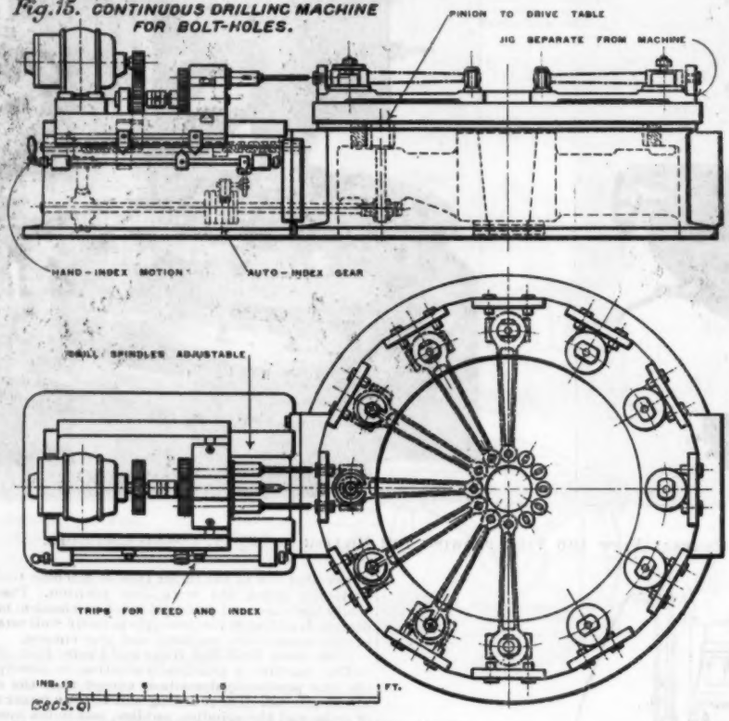


Fig. 16. CONTINUOUS MILLING MACHINE FOR SIDES OF CONNECTING-ROD.

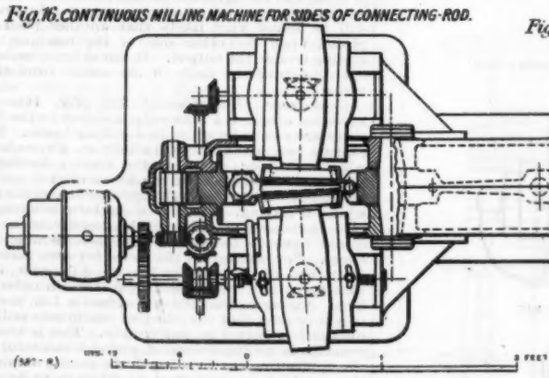


Fig. 17. DIAGRAM SHOWING DUPLEX VERTICAL MILLER FOR FACING BOLT-HOLES.

TABLE V.—SCHEME FOR MAXIMUM PRODUCTION.

Output = 60 per hour = 3,000 per week.

Operation No.	Description of Operation.	Fig. No. of Jig.	Time Required, Minutes per Piece.	Type of Machine.	No. of Machines.	Labour Cost per Piece.
						d
1	Heat treatment	—	—	—	—	—
2	File burrs, &c.	—	—	—	—	—
3	Continuous mill both ends of rod	Becker miller.	1	2-spindle circular miller	1	0·2
4	Continuous drill both ends of rod	14	1	4-spindle auto drill	1	
5	Broach small end	—	¼	Broaching	1	0·1
6	Continuous drill and centre	15	1	2-spindle double drill	1–2 head	0·2
7	Continuous mill sides of rod	16	1	Duplex continuous miller	1	
8	Mill across top of bolt holes	—	5	Horizontal miller	5	0·9
9	Mill sides of bolt faces	17	2	Duplex vertical miller	2	0·4
10	Part cap	—	5	Horizontal miller	5	0·9
11	Finish bore large end	—	20	Turret lathe	20	3·3
12	Run white metal in large end	—	—	—	—	—
13	Finish bore white metal in large end	—	19	Turret lathe	10	1·7

Fig. 18.

CURVE SHOWING RELATION BETWEEN OUTPUT AND COST OF COMPONENTS.

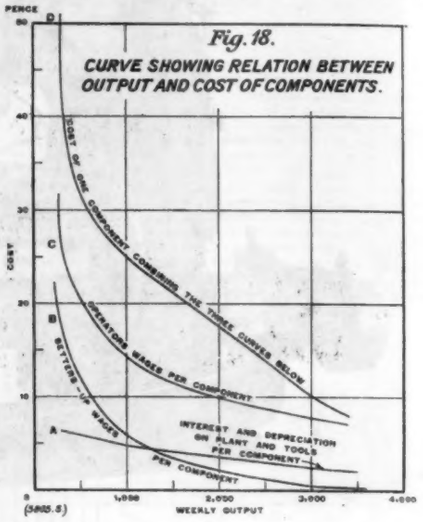


TABLE VI.

—	Small Production.	Large Production.	Maximum Production.
Weekly output	300	1,000	3,000
A Total number of machine tools involved	16	33	47
B Operator's wages (say, 10*d.* per hour), per one rod	25·9*d.*	14·5*d.*	7·7*d.*
C Setters-up wages (say, 1*s.* 8*d.* per hour), per one rod	18·0*d.*	6·0*d.*	0·25*d.*
D Total approximate value of jigs required	225*l.*	855*l.*	1,260*l.*
E Total approximate value of machine tools	2,400*l.*	5,850*l.*	9,200*l.*
F Weekly cost of plant upkeep, say, 10 per cent. depreciation, 5 per cent. interest on capital	7·9*l.*	20·1*l.*	29·4*l.*
G. Plant cost per rod	6·3*d.*	4·8*d.*	2·3*d.*
H. Total cost of rod. (Sum of B.C.G.)	50·2*d.*	25·3*d.*	10·25*d.*

increases in size. This will undoubtedly develop grinding processes rapidly, and considerable ingenuity has to be given to the order in which operations are to be performed between carbonising and quenching the piece.

The whole tendency of tool design is in the direction of more "fool-proof" jigs, therefore making more complex and larger jigs necessary. If this can be done with a degree of standardised tool parts, and with easier methods of producing precision work, to avoid trial and error settings when building the tools, there need be no fear for the development and increase of engineering production for the next few years to replace war wastage.

THE SCOPE OF THE WORKS LABORATORY.*

By FREDERICK C. A. H. LANTSBERRY, M.Sc., F.I.C., Member (Birmingham).

THE relations which should exist between a works laboratory were very ably dealt with in the paper which Mr. Barclay read before the Birmingham section some time ago. Mr. Barclay has certainly earned the gratitude of all existing and potential works chemists for the very eloquent way in which he described some of the directions in which a works laboratory could be of real practical use to industries. This paper is the result of a suggestion thrown out during the reply to a somewhat lengthy discussion, and is not therefore to be regarded as a separate dissertation, but rather as a further contribution to that discussion. It is not overstepping the mark to say that the future industrial prosperity and commercial supremacy of our whole Empire depends to a very large extent upon the application of science to industry, but nevertheless it is a somewhat appalling thought that only the shock of the most disastrous war which has ever stemmed the tide of civilisation could bring home to industry the desirability of a closer union with science. Even now it is doubtful if the advantages to be gained from a proper application of science to industry are recognised to anything like the extent they should be. The view "of course it is the patriotic thing nowadays to employ Doctors of Science and those sort of people, but when the war is over we shall be able to do without them" has been expressed. This is no doubt an extreme case, and it is exceedingly gratifying to report that such feeling does not exist in the metallurgical and engineering industries. In these industries, at least, there can be no doubt that the laboratory has come to stay. And why? Because it has proved its value. The fact that the laboratory has come to stay because it has proved its value is a most important one, which should be taken to heart not only by the captains of industry, but also by all laboratory workers. Since, therefore, there is in one section of industry an indisputed demand for trained scientific workers, it is highly desirable that the demand should be catered for as widely as possible. In this connection it is quite futile to quote as examples Germany and America, for granting the fact that a closer application of scientific principles has contributed to their rapid rise in the industrial and commercial worlds, their cases are not parallel with ours. The great Anglo-Saxon stock from which we have sprung has always been a pioneering race with originality for its most powerful characteristic, and to graft on to that character the Teutonic attributes of copying and exploitation would be a great national disaster. Rather let us seek out some method of our own, and in its development use our natural judgment in determining the modifications which seem to be advisable in view of what has occurred in other countries. They have undoubtedly made mistakes by which we should profit, for herein lies the key of progress. Perfection is an ideal which can only be strived after; it is not within human capacity to attain it, and after all, the perfect world would probably be a poor sort of place to live in.

The statement of the problem is very simple—on the one hand we have that most fascinating study science, and on the other hand industry, on which our greatness as a nation depends, for after all it is the industry of a nation and not its "will to conquer" which determines its ultimate greatness; the problem is to determine how the two can be harnessed together so as to be of the maximum use to each other. We hear so much of the benefits which will accrue to industry by the application of science to it, that we are apt to overlook the fact that industry has been of incalculable help in scientific development by supplying it with many complex and fascinating problems, and the recognition of this fact by the scientific worker is of equal importance, with the recognition by the manufacturer of the benefits which his particular industry will derive through the assistance of science. Obviously the first thing to do is to provide a laboratory; not a very difficult matter in these days, when manufacturers are even prepared to co-operate in their upkeep. At the very outset it is essential to confine our attention to some particular type of laboratory, for since there are over 20 different branches of industrial chemical activity, it might be assumed that there must be essential differences between the functions of the laboratory in a fine chemical works and that in an engineering works; but a closer inquiry indicates that the differences are only in matters of detail. Differences in detail will always occur; for if they arise in no other way the human element will create them. In such an inquiry as this we can only consider general principles and leave details to look after themselves; far too many promising schemes are nipped in the bud by a too early attention to detail. To avoid confusion, however, our attention will be confined entirely to the type which should be formed in works engaged in the production or use of metals, for both these works will require laboratories of similar type and equipment. It is not within the scope of this paper to discuss design and equipment; these will depend largely on the staff, for each man will have his own particular method of attacking a problem put to him. The equipment, however, should include a technical library, and the staff should have access to current technical literature in all languages which they are capable of reading. Mr. Barclay has already outlined the work which a laboratory should undertake—in brief, his paper means that the works laboratory should be held responsible for the quality of the raw material and materials incidental to manufacture coming into the works, and also for the quality of the finished products. Such responsibility should have a very wide interpretation, probably wider than many chiefs of laboratories would like to see. It should not merely consist in writing out analytical reports and consigning them with a sigh of relief to some poor overworked works manager. Such procedure usually results in their being lost amongst other documents which are apt to accumulate on his desk. Properly interpreted there can be no question as to the utility of analyses, and wrongly interpreted they are worse than useless because they mislead, and the proper interpretation of analyses can only be done properly by some responsible member of the laboratory staff. I remember some time ago listening to a most interesting lecture on "The Worries of a Works Manager" before one of our engineering societies. The lecture was quite a long one, but in spite of this there was no mention of the interpretation of chemical analyses. In cases of doubt as to the quality of raw materials it should be one of the duties of the laboratory to take up the question directly with the suppliers, and not through the intermediary of a third party. Then less would be heard of such foolish actions as the rejection of a batch of material because analysis shows it to contain 0·033 per cent. of a certain impurity, while the specification demands that it shall contain not more than 0·030 per cent. Such an arrangement would prevent woeful misinterpretation of results, and incidentally would cut down the amount of transport carried out on the material, for there can be no doubt that such material frequently finds its way back again to the user, disguised under another batch number—a fate it so justly merits after rejection on such trivial grounds. In addition there is the added advantage that the laboratory would take greater care in sampling and in carrying out its tests. In cases where works are enabled to afford the luxury of a buyer such a scheme need not necessarily cause clashing between the laboratory and the purchasing department. Their duties should be clearly defined; the laboratory should control quality, and the purchasing department should control prices after the quality has been settled. In a good organisation there is ample scope for both departments, and they should be encouraged to work in closest co-operation. It frequently happens in a works that unnecessarily high prices are paid for certain materials because of groundless fears of using cheaper ones, whilst on the other hand false motives of economy in purchase often lead to vastly increased costs of production. In this respect the laboratory can be of immense practical use in making a study of the effects of variation in composition and physical condition upon the costs of production, and for this purpose a knowledge of prices is absolutely essential.

Another function of the laboratory should be to carry out research with the objects of discovering new products and processes and of introducing improvements into existing ones, and this function is the one most likely to appeal to the trained scientific mind. This branch of the work will include the investigation and rectification of faults. The last function is one which has already been dealt with by Mr. Barclay, and is the one which gave rise to the controversy in the discussion of his paper. Direct control should be exercised over all processes of a purely chemical or metallurgical nature, such as smelting, refining, remelting, annealing, heat treatment, electroplating, and so on. The determination of the extent to which the laboratory should exercise control is a very moot point. Certainly the laboratory should determine and directly control the methods which are to be adopted, but as to whether it should go further and control the questions of labour and costs is a very difficult question to answer at the present time. It depends so much on the personality of the laboratory staff. In the present state of evolution there can be few highly-trained scientific workers who have had the necessary years of experience to deal adequately with the thorny problems of labour. But the time will surely come when the complete control will have to be placed in the hands of the laboratory—the laws of evolution demand it. At the present time, however, there are very few works laboratories which have evolved sufficiently to take complete control, and it would not be fair to them to add to their already multitudinous duties. But it is not so much the object of this paper to dilate on the possibilities of works laboratories as to indicate to them, and also to the manufacturers, the methods by which those possibilities can be developed. The possibilities of a works laboratory are unlimited if the conditions are right and its work is allowed to develop on natural lines. Swamping at the outset is fatal.

Now there is a desire on the part of manufacturers to possess laboratories with an efficient staff, and there is the will to succeed on the part of the staff. So long as the two can adopt the right attitude towards each other success is assured. Right from the outset the laboratory staff should recognise that the works is not a philanthropic institution. The success of a laboratory depends upon its being able to turn its activities and accumulated knowledge into money, and is not in any way proportional to the product of the number of chemical estimations and the number of mechanical tests it can do in a specified time. Nor is success even determined by the sharpness and beauty of its photomicrographs. They are facetiously compared with the moon. The laboratory must be a really live institution, with a determination to get right down to rock-bottom facts. It does not assist the man in the works in the slightest degree to receive a report typed on a fancy sheet of paper over a flourishing signature explaining that a certain piece of metal has failed because "a microscopic investigation, under a linear magnification of 1,000 diameters, of a longitudinal section after etching in a 2 per cent. solution of metanitrobenzol-sulphonic acid in iso-amyl alcohol indicates that the γ solid solution has not completely split up into the α and β phases." Unless the laboratory can determine the real cause of the failure and indicate how such defects can be avoided in future, it has failed in its functions. It must get into touch with actual working conditions, learn the language of the works, and exert a friendly educating influence. Its attitude towards the workmen must be a sympathetic one, and endeavours should be made to bring about improvements by assisting the natural processes of evolution which we cannot fail to see going on around us. The writer of a leading article in *The Metal Industry* has pointed out that "a great deal of harm has been done in the past through the scornful contempt with which many skilled workmen have been regarded by enthusiastic university men and chemists." Rather should they marvel that such progress has been made under such trying conditions. There are always good reasons for carrying out operations in a certain way, although there may be still better ones for doing them in different ways. The resentful attitude towards changing long-established customs is a perfectly natural and honest one, and Mr. Heathcote was quite right in regarding with suspicion the man who does not start off by opposing suggested alterations. Experience is a most valuable factor and should be given serious consideration, and until the laboratory has gained the confidence and co-operation of the practical man it has still a long way to go before it can reach the pinnacle of its utility. The practical man can give invaluable help in working out little details which are essential to the success of any scheme, and once his confidence is gained he becomes a most useful constructive critic. Not that there is any truth at all in the mouldy old adage "an ounce of practice is worth a ton of theory." This is usually the last resource of the individual whose reasoning faculties are exhausted. The age when theory and practice were considered antagonistic is as dead as the dodo. Theory and practice must work hand in hand, and if the practice is successful and the theory does not fit in with it, then must the theory be "modified" or consigned to the scrap-heap, where it will not be lonely. The staff of a laboratory must get out into the works and make a detailed study of things as they are and why they are as they are, for only in this way can any real and lasting improvements be effected. It is frequently thrown at scientific men in general, and the chemist in particular, that they are woefully lacking in tact, sense of proportion, common sense, knowledge of the human element, and so on. But all these faculties can be acquired to a very large extent, and the method of doing it is to practice self-control. A man who can manage himself is on the right road, and has made a good start towards the management of others. The main value of experience lies in the knowledge of the human element which can be gained thereby.

In the discussion on Mr. Barclay's paper, Mr. Heathcote very wisely pointed out that when a laboratory is installed in a works not only is the laboratory being tested, but simultaneously a test is being made of the fitness of the works to possess a laboratory, and very frequently the failure or incomplete success is due entirely to the attitude of the works. But it is not intended to arraign manufacturers for their past sins—it would take too long. Past sins are generally the result of ignorance, and the time will be much better spent in attempting to educate manufacturers in the way they should use a laboratory, and the treatment which they should mete out to it. Just as a plea has been put forward to the laboratory to adopt a sympathetic attitude to the works, so must the works extend a sympathetic and welcoming hand to the laboratory. The manufacturer must be imbued with the right scientific spirit, and must be prepared to take the laboratory into his fullest confidence. It must be recognised that the task set is a most complex and difficult one, and one which is not rendered simpler by the fact that its activities are bound to meet with a certain amount of opposition born of prejudice. The scientific worker must be given a status which is at least equal to that of the barrister, lawyer, or doctor. And, after all, why should it not be so, for is not his training as rigorous. The manufacturer must recognise that to the scientific worker a knowledge of chemistry, physics, the principles of engineering, mathematics, metallurgy, drawing, geology, and modern languages are absolutely essential. Is the man who has the intellect and patience to acquire a knowledge of these subjects to be treated lightly? Mr. Heathcote was quite right when he said that omniscience was demanded of a works chemist. Under existing conditions a chemist was expected to possess, in addition to his knowledge, common sense, adaptability, powers of observation, intuition, and a hundred and one other faculties which are commonly regarded as gifts of nature. If he does not happen to possess them he is voted a failure and treated with scorn. To a very large extent the scientific worker has never been given the opportunity to develop these faculties. How often is the complaint heard that a chemist of undoubted ability able to make important discoveries and is yet incompetent to put them on a sound commercial basis. Should this count to his discredit? Certainly not, particularly when it usually acts to his own personal disadvantage. Business ability should no more be demanded in a scientific investigator than should scientific ability be demanded of a sales manager. The very existence of

* Paper read before the Institute of Metals, on Wednesday, March 26, 1919.

commercial ability almost postulates an inferior degree of scientific ability, because commercial ability demands as its reward financial success, which has certainly not been afforded by a scientific career up to the present. The application of science to industry is in the process of evolution; at the present time the demand for the scientific worker exceeds the supply, and the best way out of the difficulty is for the manufacturers themselves to take a hand in the proper training of promising material. Then we shall hear very much less of the ineffectiveness of the scientific worker, because the manufacturer will take care that the product he has helped to mould shall have suitable opportunities to develop those faculties which the chemist is blamed for not possessing. In the past low wages to the chemist have been the rule. Considerable complaints have been raised from time to time against this, but it ought to be more widely understood that the scientific workers' objection is not so much against low wages but against the fact that his abilities have not been given proper scope so that he could prove his true economic value. Modern industrial conditions demand capital, brains, and labour, and the impression that they are antagonistic is just as fallacious as the idea of science opposing practice. Rightly or wrongly, there is a considerable feeling in the country that in the past more than the due share of the reward has accrued to capital. Already there is a movement on foot for a closer union between labour and the brain workers of the country. The best and most lasting reforms are those which come from within—a fact which capital would be very wise to take to heart. But this is diverging somewhat from the subject, but in regard to the question of financial reward it is important to bear in mind that it is most desirable that the possibilities for the scientific worker in this respect should be such as to attract the highest type of brain into the profession. Another important point is that the laboratory staff should consist of a sufficient number of men of the right type, men of proper training, to take advantage of the opportunities to be offered to them. And even when all these things have been attained the laboratory must not be expected to perform miracles in the tying of a cravat. The development of new, and the improvement of old, processes demands research, often of a most intricate and difficult nature, and it is given to few manufacturers to realise the difficulties of research, even when the research is assisted by the element of luck. The completion of every piece of research renders succeeding ones more and more difficult, and it must not be forgotten that once a research is brought to a successful issue its results stand for all time.

The success of a laboratory depends therefore on :—

1. Possession of a proper equipment, which includes an ample number of properly trained scientific workers.

2. Mutual existence of the right attitude of mind between the works and the laboratory.

3. Complete confidence and sympathetic assistance of the management, more particularly with regard to those matters requiring what may be described as commercial ability for want of a better term.

It is not intended to say very much with regard to the training of chemists, although it is pretty obvious that this will exert a large if not deciding interest on the degree of success. The subject was very thoroughly thrashed out in the Journal of the Society of Chemical Industry for 1908. Difficulties have arisen in the discussion of the subject, because manufacturers complain of teaching institutions being too academic and expect them to turn out finished technologists. Even if this were possible, it would take from ten to fifteen years, during which time the opportunity of becoming acquainted with the human element is cut down to a minimum. Teaching institutions can do their best work by giving their students a thorough groundwork in the fundamental principles of chemistry on a very broad basis. This in itself is no light task, demanding as it does a contemporary grounding in general physics and mathematics. A man with a good all-round training will be competent to take a post in any of the numerous branches of the industry. At the conclusion of the training, which will take three years at the least, a certain amount of original research work should be necessary for the granting of the diploma. The final training of the trained chemist into a technologist cannot be carried out in a teaching institution. The necessary practical bias can be introduced into the training by the introduction on to the teaching staff of highly qualified men who have made good in industry, and by insisting on the necessity for real practical experience on the part of teachers. Serious consideration should not be given to the charge that chemists lack commercial and controlling ability. Up to the present time they have had little or no opportunity of demonstrating whether they possess it or not. If it so happened that some particular individual did not possess such ability, it is certain that he would be given neither chance nor assistance to develop it. If the desire of industry for the assistance of scientific knowledge is real its duty is clear. It must take a definite and positive interest in the training of the potential technologist, not only in assisting teaching institutions, in the acquirement of a staff, but also in promoting and influencing research. But certainly its most important function lies in the direction of the provision of adequate scope and opportunities for the industrial laboratories.

PROPOSED NEW DRY DOCK AT LULEA.—The construction of a dry dock at Lulea is at present under consideration, and seems likely to be undertaken. The need for a dry dock in these northern parts is fully realised, and Lulea appears to have the prior claim, mainly on account of the important ore shipments from this place.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Transition periods are invariably difficult to manipulate and yet, considering the great changes which have taken place during the past four months, it is astonishing to find things running so smoothly in trade and industry. The uncertainty of the future still gives much cause for anxiety, and makers and buyers alike are chary of doing any business except that of the most urgent nature; the immediate requirements alone are entertained. All the available steel plant is fully employed, and heavy outputs are the result, and with this the feeling that this activity may continue for some considerable time gains ground. The prospective advance in prices, caused by the increased cost of production, is not viewed with much favour by consumers. Until transport conditions show signs of improvement but little export business can be put through, so that producers are conserving all their energies towards supplying the demands of the home consumers—the wisest policy meantime, especially looking towards the shipbuilding activity, which is steadily on the increase.

Malleable Iron Trade.—Malleable iron continues in active demand for home consumption only, very little of the output being available for shipment overseas. Sections for engineering, shipbuilding, agricultural purposes are greatly in request, and as orders are constantly coming to hand there is no lack of good business. The increase of 30s. per ton in the price of bar iron for home use may have a restraining effect, but as the general consumer has suffered severely through insufficiency of supplies during the years of war, the chances are that anything of this nature may only be temporary and transient. For home delivery, 17*l.* 15*s.* per ton is now being charged for "Crown" bars on trucks at the works while for export the exorbitant figure of 20*l.* per ton is being quoted. At this rate no great development can be looked for.

Scotch Pig Iron.—Quite a good volume of business is being put through in the pig iron industry, the producing works being as fully employed as is possible with the labour at command. Certainly the unsettled feeling which has endured for the past two or three months is not advantageous to the best interests of the industry, but it is hoped that a satisfactory adjustment may be effected by the end of the month when subsidies are removed. Meantime every ton of the output is rapidly absorbed in the home markets, despite the fact that buyers are acting cautiously and with reserve. Export is still dull and lifeless, and likely to remain so for some weeks longer until prices are definitely settled and arrangements made for expansion.

Clyde Shipbuilding.—Clyde shipbuilding is coming away most satisfactorily, and during the month o March the output consisted of 32 vessels of an aggregate tonnage of 40,310 tons. These vessels have been built by various firms to the order of the Admiralty, the Shipping Controller, and several private owners, and amongst the largest are steamers constructed at Glasgow, Greenock and Port Glasgow, while the smaller craft includes mine-sweepers, cargo steamers, tugs, &c.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While enquiries for contract work are on the increase, the number of orders actually booked appears to be comparatively small. Manufacturers are badly handicapped in offering quotations, because of the uncertainty of values of raw material, and the difficulties of delivery. Big contracts are known to have been placed abroad. One of the largest of recent requirements was for 750,000 tons of steel rails for reconstruction in Northern France. The English manufacturers' quotations for bare net cost of production was 30*s.* per ton higher than that of American makers. Hence the first 500,000 tons have gone to America, and the remaining 250,000 tons are likely to follow, if they have not already gone. But although American competitors appear to be receiving a big share of current business, South Yorkshire manufacturers are not unduly depressed. Sir Robert Hadfield expresses the opinion that when the difficulties of reconstruction are overcome, British manufacturers will show themselves capable of competing in any and all parts of the world. One of the chief problems of the moment is the difficulty, in certain branches of the steel trade, of securing sufficient skilled labour. The several thousands of unemployed do not, apparently, include many highly-skilled hands, who have very little trouble in placing their labour. The demand for semi-skilled and unskilled men, on the other hand, is small. An important decision, which has reached Sheffield manufacturers this week, is that the Foreign Office has resolved no longer to prohibit British firms from endeavouring to recover, through intermediaries in neutral countries, debts owing to them by enemy firms or individuals. Steelmakers are demanding increased prices from April 1. Very little iron is obtainable on the open market, business being retarded by the removal of subsidies. Furnaces continue to work short time, but there is no evidence of slackness at the rolling mills or forges. Both crucible steel and high-speed steel, however, are in reduced demand. Makers of tool steel have been trying to combat the prohibition on exports to France and Italy, but without material success. Owing to the attitude of the French and Italian Governments, special permits are required, and the delay occasioned in the granting of these is seriously hampering business. Because of the widening of the margin between the values of old and new scrap, following the advance of steel prices, holders are adopting a conservative attitude, and business for the moment is of a restricted character. Uniform activity prevails in the lighter branches. Several new file-making departments have been opened to cope with the increased requirements. Pressure on the output of saws, small tools, and cutting machine parts is also great.

South Yorkshire Coal Trade.—The unauthorised holiday taken by many local colliers, and the consequent closing down of several pits, threatened to have a serious effect on iron and steel manufacture. Works' stocks, already low, were in many instances practically exhausted, and in the case of smaller concerns, managements were considering suspension of production. Fortunately, the pit workers adopted a more reasonable attitude, and on Monday work was again in full swing. The general situation is very difficult. Supplies of all kinds of fuel are below requirements. Railway companies and electricity-producing concerns are urgently pressing for larger tonnages. Open market sales are restricted to a few odd lots at maximum rates, values being more or less nominal. The demand for cobbles, nuts, slacks, and coke is in each case more than equal to the output. Conditions are no easier in the house coal section. Merchants are besieged with enquiries, and have many arrears to make up. Quotations :—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Firmness still characterises the market, but business in Cleveland pig-iron is very quiet, transactions, in fact, being almost confined to early sales of forge quality to home consumers, foundry kind being exceedingly scarce. Buyers and sellers alike are disinclined to enter into contracts beyond the end of this month, when the State subsidy ceases. It is fully realised that so soon as control is removed values will advance, but to what extent opinion differs very widely, and consequently there is no basis for business beyond the present month. The opinion prevails that the Government will not permit inflated prices to occur to an extent that may seriously disorganise trade, and the suggestion is once more put forward that producers may fix a minimum price. The truck shortage, though certainly not so acute as it has been, is still seriously felt, and hampers distribution considerably. Foreign business is almost at a standstill. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge, all stand at 95*s.*; and No. 1 is 99*s.*; and for export No. 3 and the lower qualities are 145*s.*; and No. 1 is 150*s.*

Hematite Iron.—Now that production of East Coast hematite iron has considerably more than overtaken home needs, licences for export are less difficult to secure. Such permits, however, are still granted with caution, though stocks are said to be accumulating, and demand on Continental account is stated to be rather less pressing. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 172*s.* 6*d.* for export.

Foreign Ore.—There is slightly more enquiry for foreign ore, but very little actual new business is reported. Consumers are well placed, having very substantial stocks, and as they hope for and anticipate a fall in freights they are holding off in the expectation of making contracts on more favourable terms than are at present obtainable. Up to the present there does not appear to have been any chartering Bilbao-Middlesbrough at below 20*s.*, which is 3*s.* above the recent parity.

Coke.—Coke is by no means abundant, but satisfactory deliveries are being made regularly to the local blast furnaces. Average furnace quality is 33*s.* at the ovens; and low phosphorus sort 35*s.* 6*d.* at the ovens. Foundry coke for neutrals runs from 70*s.* to 75*s.* f.o.b., and gas-house product 70*s.* to 72*s.* 6*d.*

Manufactured Iron and Steel.—There is little new to report concerning the various branches of the manufactured iron and steel industries. Producers have a lot of work on hand, and there are good home and foreign enquiries in the market. At the Cargo Fleet Works suspension of operations has enabled a partial clearance of the stock-yard, and the re-stocking of the steel-mills; whilst at Clarence the coal shortage has been overcome, and the steel-works are in full swing again. It is stated that the North-Eastern Steel-works are to be entirely re-constructed. To home customers principal prices stand :—Common iron bars, 17*l.* 15*s.*; steel ship, bridge and tank plates, 14*l.*; steel boiler plates, 15*l.*; chequer plates, 15*l.* 10*s.*; steel angles, 13*l.* 12*s.* 6*d.*; steel joists, 13*l.* 12*s.* 6*d.*; steel billets and blooms, 12*l.* 5*s.* to 12*l.* 15*s.*; and steel rails, 13*l.* 10*s.*; whilst the following are among the principal export quotations :—Common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel angles, 16*l.* 2*s.* 6*d.*; steel joists, 16*l.* 2*s.* 6*d.*; billets and blooms, 13*l.* 10*s.* to 15*l.*; and steel rails, 15*l.* 10*s.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during March totalled 33,815 tons, of which 12,200 tons were pig-iron, 517 tons manufactured iron, and 21,098 tons steel. Of the pig-iron despatched, 5,440 tons went coastwise, and 6,760 tons to foreign ports; of the manufactured iron loaded, 157 tons went coastwise, and 360 tons went abroad; and of the steel cleared, 1,821 tons went coastwise, and 19,277 tons went foreign. France was the

largest customer for pig-iron, taking 4,420 tons, the United States of America being next with an import of 1,000 tons. Japan received 153 tons of manufactured iron, and France 148 tons. Japan was the biggest buyer of steel, taking 5,761 tons, whilst Spain received 4,062 tons; France, 3,604 tons; the Straits, 1,068 tons; India, 1,032 tons; and Shanghai, 1,027 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Most of the 75,000 South Wales miners who were out on strike last week have returned to work. The stoppage at Messrs. Guest, Keen and Nettlefolds' Dowlais pits, affecting about 5,000 men, continues, and on Monday the men at the Ebbw Vale Company Collieries, at Ebbw Vale, numbering about 5,000, also ceased work in connection with a dispute over allowances. The latter trouble has been considered by the Joint Disputes Board of the Conciliation Board, and a temporary arrangement made whereby the men have returned to work pending an inquiry into the dispute. A delegate conference of the South Wales Miners' Federation have recommended the miners to ballot against the acceptance of the Sankey Report, though the Miners' Federation of Great Britain recommended the miners to accept the terms offered by the Government for a settlement of their claims. In these circumstances the labour outlook in this district is still uncertain and not conducive to business activity. There is a good inquiry for all sorts of coal with the exception of the inferior smalls. New business, however, is slow, as colliery owners and exporters are busy with commitments that should have been carried out in the past week, but were held up by the unauthorised stoppages in the coalfield. Many boats are still waiting in dock for cargoes, and some have been held up for a fortnight, more especially those waiting for cargoes for neutral countries. The requirements of inland consumers is still heavy, and the Admiralty are also heavy takers. Consequently there is little coal available for shipment abroad and for neutrals; except in special cases, it is very difficult to get coals released. For prompt and early loading most collieries are fully stemmed. The pressure at the local docks is not quite so tight owing to a shortage of coal, but now that the majority of miners are at work it is expected that all available tips will be kept going at top speed in the course of the next few days.

The Newport Market.—The Monmouthshire collieries were not so much affected by the unauthorised stoppages as other parts of the coalfield, for the miners in this district were only out for one day. There has been a strong demand for Newport coals and, with plenty of tonnage in the Newport docks, export business has been brisk, though shippers experienced difficulty in obtaining releases as the requirements of the authorities and inland works remain very pressing.

Trimmers and Shorter Hours.—Negotiations are still proceeding for a settlement of the coal trimmers and tippers' claim for a shorter working week and an increase in pay, and hopes of an early agreement are high. A general agreement has been reached so far as Cardiff, Penarth and Barry is concerned, but the application of a shorter working week for Swansea, Port Talbot and Newport is to be a matter of further local negotiation. The hours recommended for the former ports is 84 a week, composed of a day shift from 8 a.m. to 5 p.m. and a night shift from 9 p.m. to 6 a.m., with an hour's meal break in each shift, and a Saturday shift from 8 a.m. to 12 noon. Minimum standard payment has been recommended for the tippers.

Cardiff Shipping Deal.—Messrs. Jenkins, Richards and Evans, Limited, managers of the Maindy Shipping Company, Limited, Cardiff, have acquired the whole of the fleet of six steamers owned by Messrs. Howard-Jones and King, Managers of the Tree Steamship Company, Limited, Cardiff. The Maindy Company now possesses a fleet of 10 steamers of about 45,000 tons deadweight. No financial details of the transaction have transpired.

Miscellaneous.—Mr. T. J. Callaghan, of Messrs. L. Gueret, Limited, coal exporters, Cardiff, has been re-elected president of the Cardiff Chamber of Commerce, and Mr. R. O. Sanderson, shipowner, and Mr. W. R. Hann, of the Powell Duffryn Coal Company, have been re-elected vice-presidents of the Chamber.

ISSUES OF CAPITAL UNDER PRIVATE ACTS.—The Lords Commissioners of His Majesty's Treasury give notice that, in view of the relaxation of restrictions on capital issues, borrowing powers conferred by private Acts subject to Treasury assent being obtained, for any exercise of those powers during the war period, may now and until further notice, be exercised by the local authorities and others concerned, for capital purposes within the United Kingdom, without further authority from the Treasury, than is given by this notice.

PETROL SUPPLIES.—Sir Marcus Samuel, speaking at a meeting of the Commercial Motor Users' Association (Incorporated), on the 2nd inst., said that in his opinion there was not the slightest danger of a failure in the world's petrol supply. If the entire supply from the United States failed to-morrow there was enough in the rest of the world to meet requirements. Sir Marcus also stated that the present stocks in this country were enormous, that storage was full to overflowing, and that it was almost impossible to land a cargo.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 4, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W. Lecturette by Mr. J. P. O'Callaghan, F.R.S., "Modern Methods of Water Treatment."

THE MINING INSTITUTE OF SCOTLAND.—Saturday, April 5, at 3 p.m., the 42nd annual general meeting will be held in the Royal Technical College, George-street, Glasgow. Business, in addition to that usual at an annual general meeting, includes:—The new President, Mr. Robert M'Laren, M.P., will deliver his Presidential Address; Professor F. W. Hardwick's paper on "The Training of Students in Coal-mining with special Reference to the Scheme of the Engineering Training Organisation," will be discussed; Mr. David Penman's paper on "A Digest of the First Report of the Mines Rescue Committee," will be discussed; Mr. P. A. Mossay's paper on "Cooling of Electric Motors, with Special Reference to Totally Enclosed Motors," will be discussed; Mr. James Cooper's paper on "The Electric Head-Lamp," will be discussed; members who cannot be present are invited to contribute to the discussions by written communications, which should be forwarded to the Secretary on or prior to the date of meeting.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LANCASHIRE BRANCH.—Saturday, April 5, at 4 p.m., in the College of Technology, Manchester. Mr. Jas. Bagley, Assoc.M.S.T., of Farnworth, will give a paper, entitled "Notes on Cupola Practice."

THE SOCIETY OF ENGINEERS.—Monday, April 7, at 5 p.m., in the rooms of the Geological Society, Burlington House, W. The proceedings will open with a social gathering of members and visitors, after which a Lecture will be given at 5.30 p.m. on "Modern Explosives," illustrated by specimens of the principal explosives and experiments with them; by Professor J. Young, of the Royal Military Academy, Woolwich.

THE ROYAL SOCIETY OF ARTS.—Monday, April 7, at 4.30 p.m. Cantor Lecture: "Problems of Food and their Connection with our Economic Policy," by Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S. (Lecture II); Wednesday, April 9, at 4.30 p.m.: Ordinary meeting, "Housing and Infant Mortality," by Mr. Leonard Erskine Hill, M.B., F.R.S., Director of the Department of Applied Physiology, Medical Research Committee. Sir Thomas Barlow, Bt., K.C.V.O., M.D., D.Sc., LL.D., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday' April 8, at 5.30 p.m. Papers to be submitted for discussion:—"The Electrical and Mechanical Equipment of the All-metal Cars of the Manchester-Bury Section, Lancashire and Yorkshire Railway," by Mr. George Hughes, M.Inst.C.E.; "All-metal Passenger Cars for British Railways," by Mr. Francis Edward Gobey, O.B.E., Assoc.M.Inst.C.E. And Ballot for New Members.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 8, at 8 p.m., at the House of the Royal Society of Arts (John-street, Adelphi, London, W.C.). Discussion on "Light and Colour in Relation to Stage Production." The discussion has been arranged with the co-operation of the Critics' Circle of the Institute of Journalists, and an introductory paper will be read by Mr. J. B. Fagan, of the Royal Court Theatre.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, April 8, at 7.30 p.m., at the Rooms, 207, Bath-street, Glasgow. The annual report for the closing session will be submitted. Lecture, "The Navigational (Magnetic) Compass as an Instrument of Precision," by Mr. M. B. Field, O.B.E., Member.

THE INSTITUTION OF NAVAL ARCHITECTS.—Meetings will be held in the Hall of the Royal Society of Arts, John-street, Adelphi, on Wednesday, April 9, morning at 11 a.m.; on Thursday, April 10, morning at 11 a.m., afternoon at 3 p.m., and evening at 7.30 p.m.; and on Friday, April 11, morning at 11 a.m., afternoon at 3 p.m. The annual dinner of the Institution will be held on Wednesday, April 9, at 7.30 p.m., in the Grand Hall of the Connaught Rooms. The following papers will be read after the Presidential Address:—Wednesday, April 9, at 11 a.m.: (1) "Ships of the British Navy on August 4, 1914, and Some Matters of Interest in Connection with their Production," by Sir Philip Watts, K.C.B., F.R.S., LL.D., D.Sc., Hon. Vice-President; (2) "Naval Construction during the War," by Sir E. H. Tennyson d'Eyncourt, K.C.B., Vice-President; (3) "The Naval Construction Corps of the United States Navy," by Mr. S. V. Goodall, R.C.N.C., M.B.E. (Member). Thursday, April 10, at 11 a.m.: Proposed alteration of bye-laws relative to the admission of women. (4) "The Work of the British Marine Engineering Design and Construction Committee," by Mr. A. E. Seaton (Member); (5) "Italian Two-Floodable Compartment Cargo Steamers Built during the War," by Signor S. Orlando (Hon. Member); (6) "Some Recent Developments Towards a Simplification of Merchant Ship Construction," by Sir E. H. Tennyson d'Eyncourt, K.C.B., Vice-President, and Mr. T. Graham (Associate Member). Afternoon Meeting, at 3 p.m.: (7) "Development of Airship Construction," by Mr. C. I. R. Campbell, R.C.N.C., (Member); (8) "Concrete Shipbuilding in the United States of America," by Mr. W. L. Scott, of Lloyd's Register. Evening Meeting at 7.30 p.m.: (9) "Investigation into the Causes of Corrosion and Erosion of Propellers," by the Hon. C. A. Parsons, K.C.B., M.A., D.Sc., F.R.S., Vice-President, and Mr. Stanley S. Cook (Member); (10) "The Michell Thrust Block," by Mr. J. Hamilton Gibson, O.B.E. (Member). Friday, April 11:—Morning Meeting, at 11 a.m.: (11) "Some Experiences with Electric Welding in Warships," by Mr. W. H. Gard, C.B., M.V.O. (Member) (12) "Further Experiments on the Stress Determination in Flat Steel Plates," by Mr. J. Montgomerie, D.Sc. (Member); (13) "The Tonnage of Modern Steamships," by Mr. A. T. Wall, B.Sc. (Member). Afternoon Meeting, at 3 p.m.: (14) "Model Experiments on the Effect of Beam on the Resistance of Mercantile Ship Forms," by Mr. J. L. Kent (Associate-Member); (15) "Some Experiments on Full Cargo Ship Models," by Mr. J. Semple (Member).

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, April 9, at 7.30, at St. Bride's Institute, Bride Lane, Fleet-street, E.C. A paper will be read by Sir Wilfred Stokes, K.B.E., on "The Relationship between Wages, Output, and Improved Standards of Living, from a Practical Point of View." General Wm. Alexander, D.S.O., in the chair.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 10, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Notes on Surface Condensing Plants, with Special Reference to the Requirements of Large Power Stations." By Mr. R. J. Kaula, Member.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, April 10, at 5 p.m., at Burlington House, W., when, with the authority of the Army Council, papers will be read before the Institution describing the mining operations in the war. A paper has been prepared by Major H. Standish Ball, R.E., Assoc. Inst, M.M. (late Assistant Inspector of Mines, G.H.Q., France), on "The Work of the Miner on the Western Front," which deals with all phases of the work on the Western Front.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 11, at 5.30 p.m., a discourse will be delivered by Professor Sir J. J. Thomson, O.M., LL.D. D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution. The subject will be "Piezo Electricity and its Applications." Afternoon Lectures, at 3 p.m.:—Tuesday, April 8, Professor A. Keith, M.D., LL.D., F.R.S., Fullerian Professor of Physiology, Royal Institution, on "British Ethnology—the People of Scotland" (Lecture IV); Thursday, April 10, Professor Alexander Findlay, D.Sc., F.I.C., on "Colloidal Matter and its Properties" (Lecture II); Saturday, April 12, Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "Spectrum Analysis and its Application to Atomic Structure" (Lecture VI).

NITRATE OF SODA.—In consequence of the Nitrate of Soda Executive having completed the work for which it was constituted, it has now been decided to wind up and dissolve this body. All communications relative to dealings in nitrate of soda, and any matters with which persons or firms were in communication with the Nitrate of Soda Executive, should now be addressed to the Department of Explosives Supplies, Ministry of Munitions of War, Storey's Gate, Westminster, S.W. 1.

PRESS BUREAU.—Unless an emergency arises it is proposed to close the Official Press Bureau, Whitehall, on April 30, after which date there will be no censorship of press telegrams or of press articles, books or pictures. This will not mean that there will be any change in the provisions of the Defence of the Realm Acts or in the regulations made thereunder. They will remain binding as heretofore, but the responsibility of seeing that they are complied with will rest upon the publisher. As regards matter telegraphed abroad from this country, the responsibility will rest with the senders of the telegrams. From the above-named date the Press Bureau will also cease to issue to the press communications from or on behalf of any Minister or Department of the Government.

CONTRACTS.—The English Electric Company, Limited—in which are now consolidated the interests and activities of the Coventry Ordnance Works; Dick, Kerr; the Phœnix Dynamo Manufacturing Company; the United Electric Car Company; and Willans and Robinson—have recently secured an order for a second 18,750-kw. turbo-alternator set for the Glasgow Corporation, being a duplicate of the machine now in an advanced stage of manufacture. The contract includes, in addition to the turbo-alternator set, condensing plant and step-up transformers, and completes Mr. Lackie's first scheme of five sets for the Dalmarnock Power Station. The turbine is a single-unit machine of the firm's standard type, arranged to run at 1,500 r.p.m., and will operate on steam at 250 lb. pressure, superheated to 650 deg. F., and exhaust into a vacuum of 29·1 in. It will be coupled to a 6,600-volt, 25-cycle, three-phase alternator, having a maximum continuous rating of 24,000 k.v.a. at 80 per cent. power factor. The machine is of the self-ventilating type, and will be electrically connected to a bank of three single-phase oil-circulated water-cooled transformers, stepping-up the pressure from 6,600 volts to 20,000 volts. An overhung exciter will be provided, as also air and oil-cooling plant for alternator and transformers respectively. The condensing plant will be of the Willans' surface type, with duplicate air-extraction plants on the Willans' rotary water-jet system, and extraction pumps in duplicate.—A number of contracts for tramway material have recently been placed with Messrs. Dick, Kerr and Co., Limited, which—under the recent consolidation scheme—will be carried out by the English Electric Company, Limited. These include orders for tramway cars complete with equipments, and for car bodies, tramway motors, controllers, &c., from the corporations of Nottingham, West Hartlepool, Morecambe, Southport, Brighton, Huddersfield, Bradford, Liverpool, Manchester, Burton-on-Trent, and others.

THE INFLUENCE OF COLD-ROLLING UPON THE MECHANICAL PROPERTIES OF OXYGEN-FREE COPPER.

(*For Description, see Page* 454.)

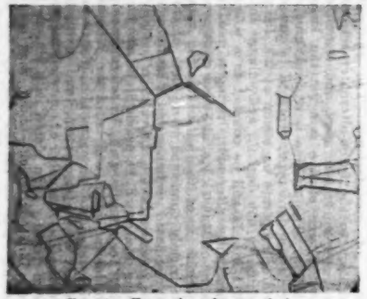


FIG. 4.—Forged and annealed.

FIG. 5.—31·8 % reduction. Rolled cold.

FIG. 6.—46·13 % reduction. Rolled cold.

FIG. 7.—62·9 % reduction. Rolled cold.

FIG. 8.—77·2 % reduction. Rolled cold.

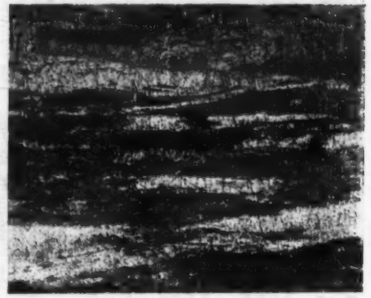


FIG. 9.—80·57 % reduction. Rolled cold.

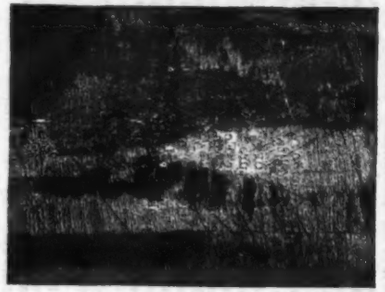


FIG. 10.—87·4 % reduction. Rolled cold.

FIG. 11.—88·96 % reduction. Rolled cold.

FIG. 12.—92·5 % reduction. Rolled cold.

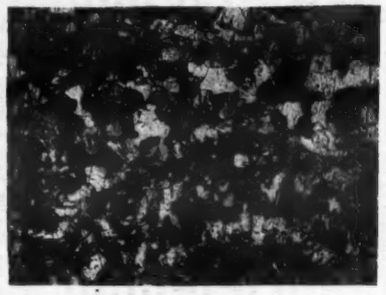


FIG. 13.—Annealed.* 62·9 % reduction.

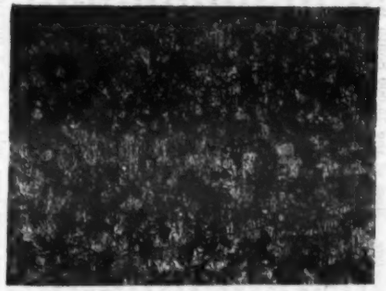


FIG. 14.—Annealed.* 92·5 % reduction.

MAGNIFICATION 100. VERTICAL ILLUMINATION. ETCHING MEDIUM: AMMONIUM PERSULPHATE. REDUCED BY ONE-THIRD.
* 750 DEG. C. FOR 15 MINUTES.

H.M. SEAPLANE-CARRYING SHIP "ARGUS"; BOIL

CONSTRUCTED BY MESSRS. WILLIAM BEARDM

(For Description, see

Fig. 18.

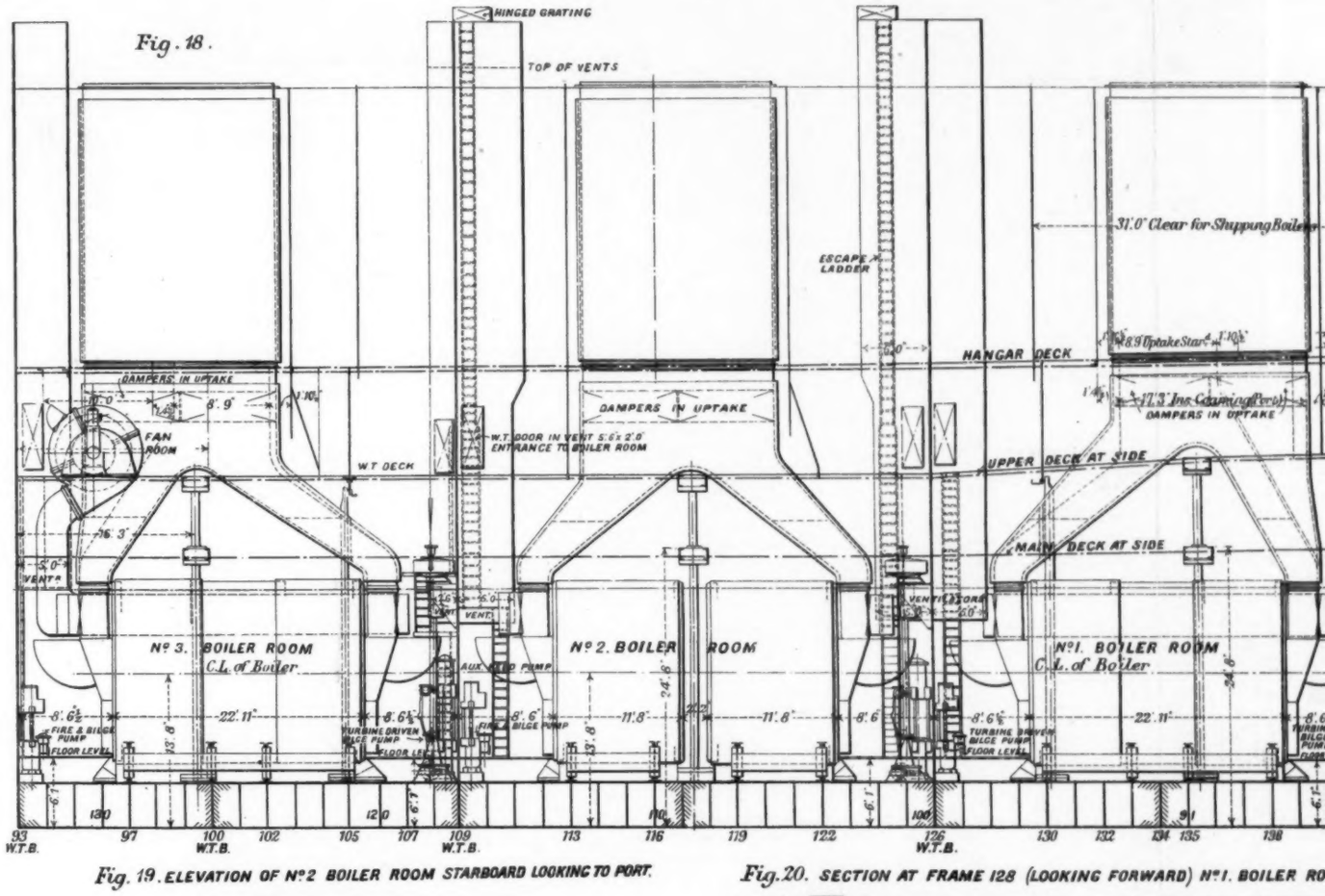


Fig. 19. ELEVATION OF No. 2 BOILER ROOM STARBOARD LOOKING TO PORT.

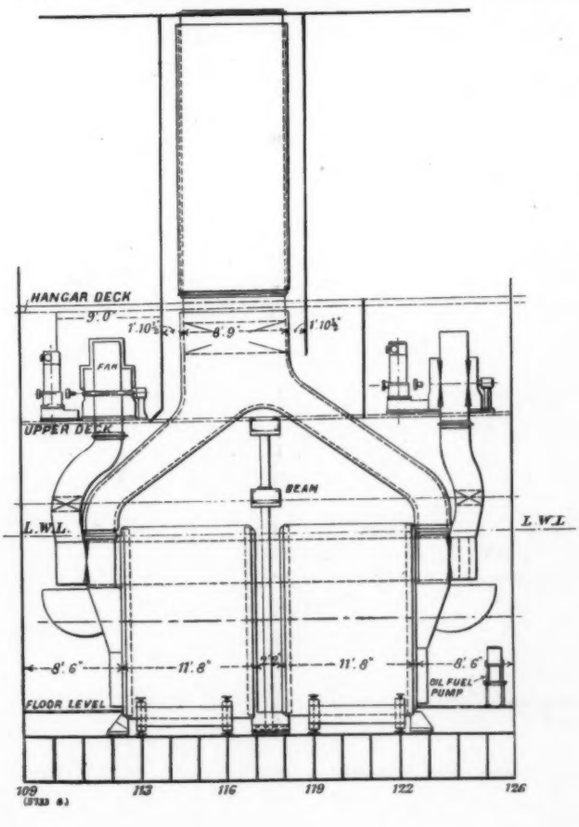
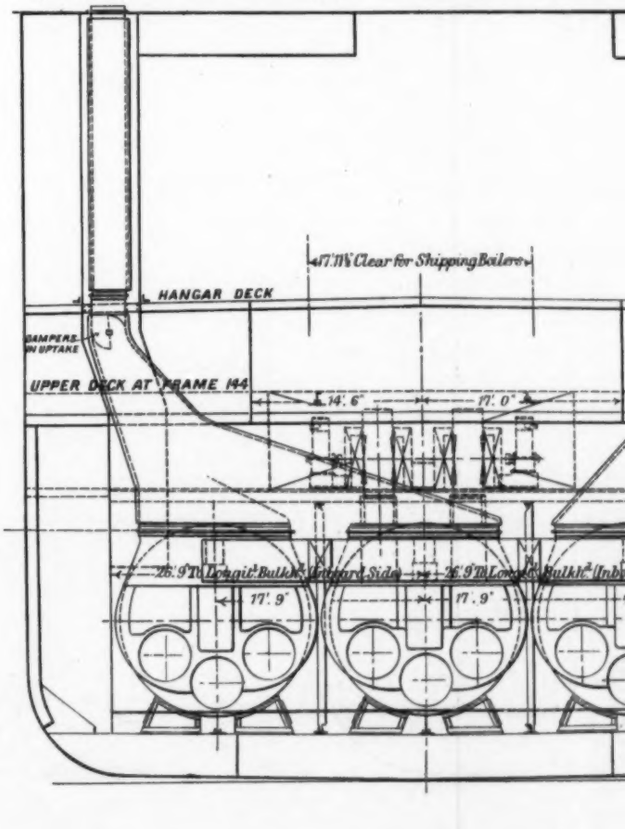


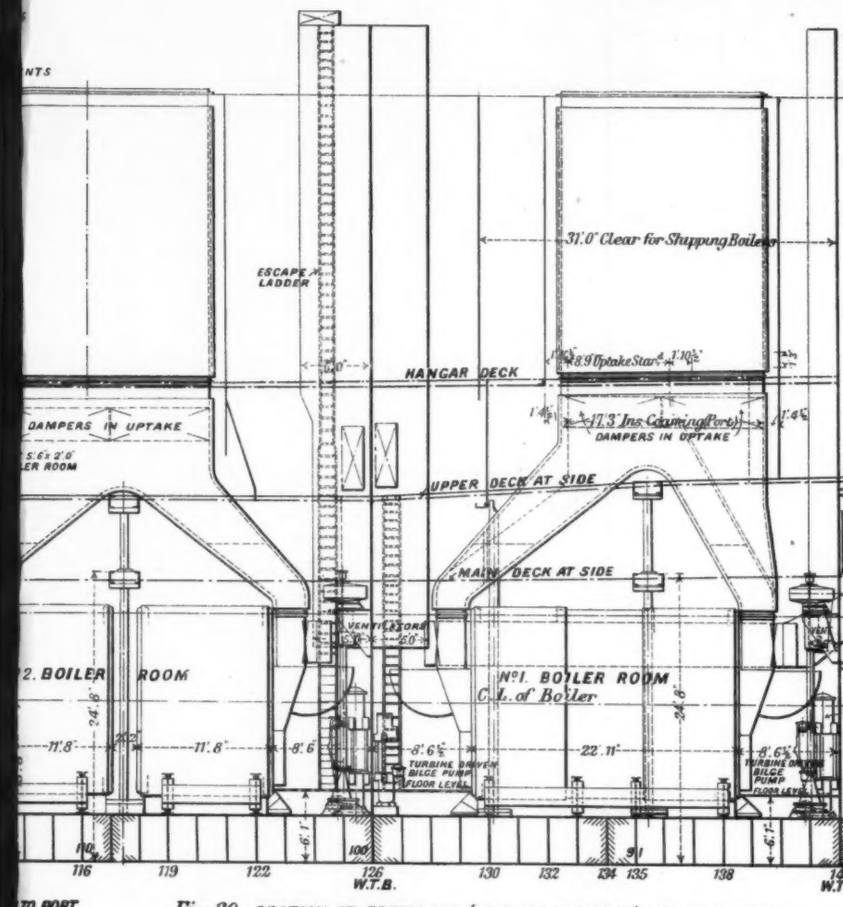
Fig. 20. SECTION AT FRAME 128 (LOOKING FORWARD) No. 1. BOILER RO



PLANE-CARRYING SHIP "ARGUS"; BOILER

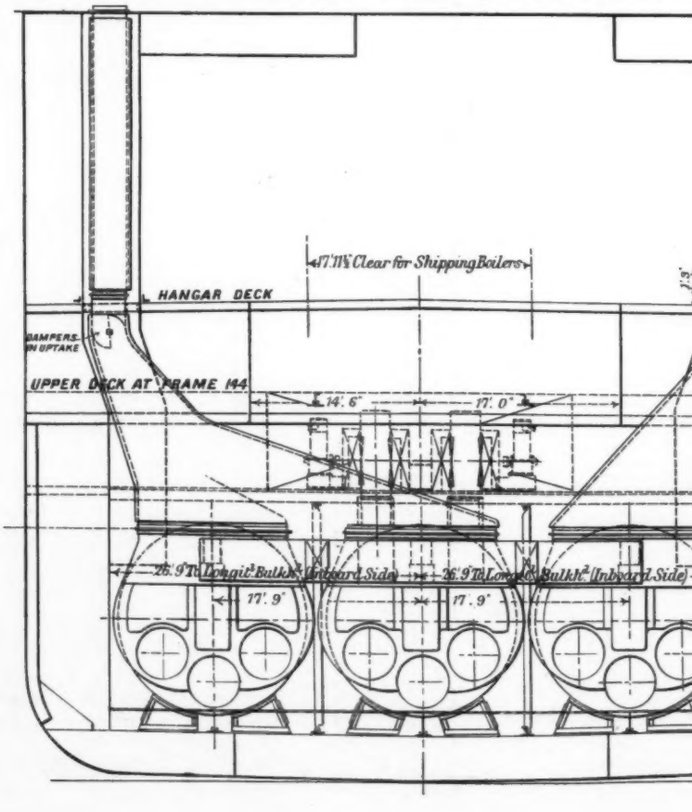
CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE

(For Description, see Page 43



TO PORT.

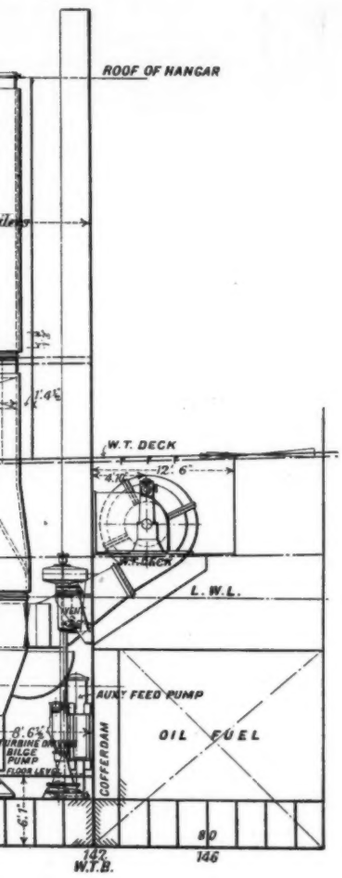
Fig. 20. SECTION AT FRAME 128 (LOOKING FORWARD) No. 1. BOILER ROOM.



ILER UPTAKES AND HORIZONTAL FUNNELS.

ARDMORE AND CO., LIMITED, DALMUIR.

, see Page 430.)



ROOM.

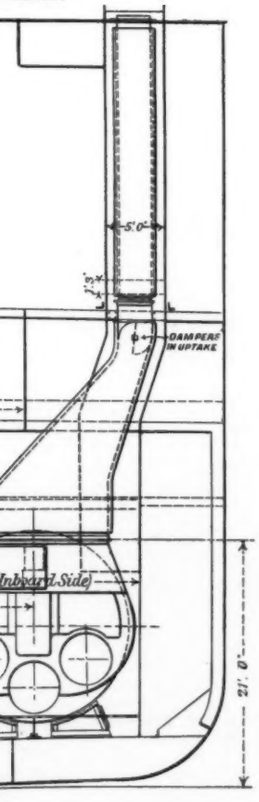


Fig. 21. SECTION AT FRAME 124 (LOOKING AFT) Nº 2. BOILER ROOM.

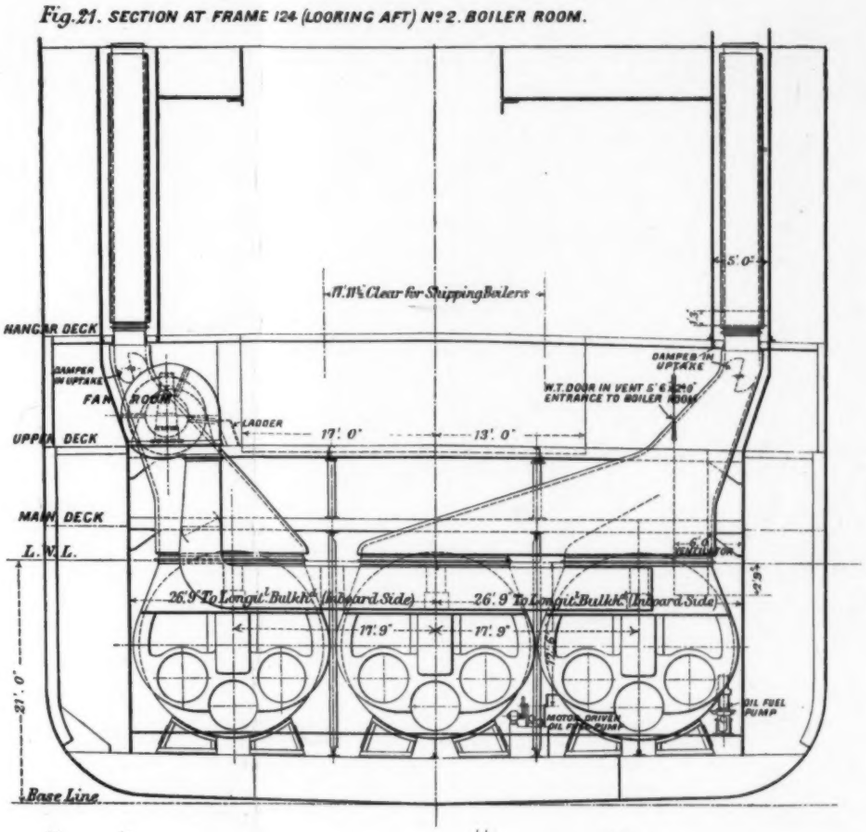
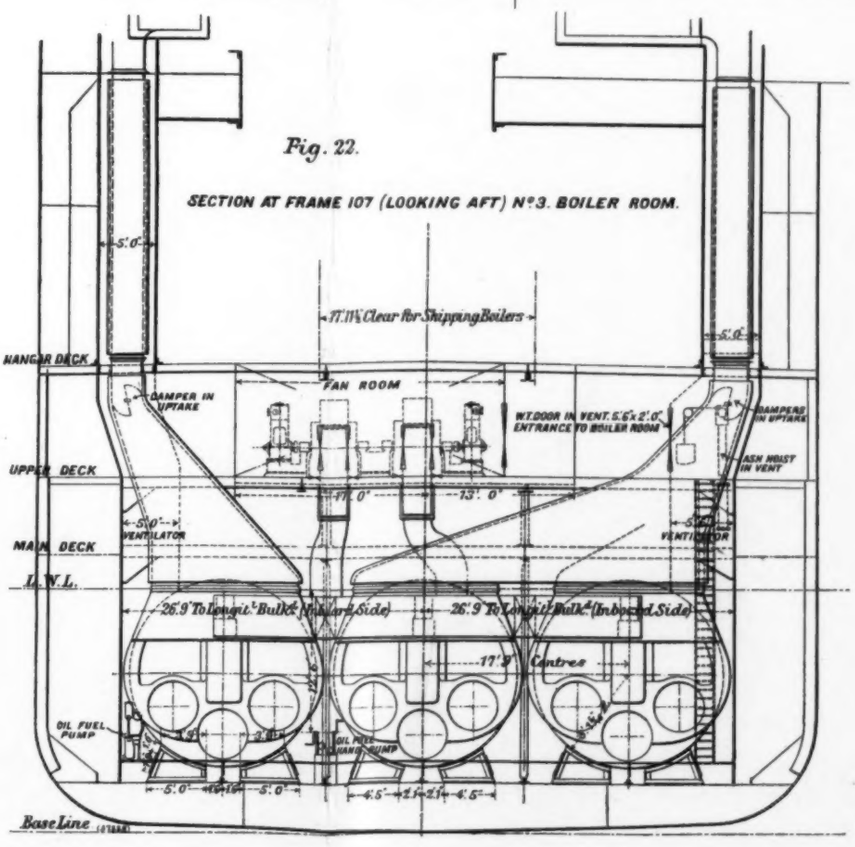


Fig. 22.

SECTION AT FRAME 107 (LOOKING AFT) Nº 3. BOILER ROOM.



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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 439.

ENGINEERING.

FRIDAY, APRIL 4, 1919.

NATIONAL AND INTERNATIONAL LABOUR PEACE.

FOR the present the black cloud of great labour troubles appears to have gone, and if one cannot altogether see the rays of the new dawn, which the end of the war was to bring, still the storm has receded, and one may at least look up into the grey of an average day. This is cause for satisfaction, and yet something more is needed if we are to go forward with the lightness of heart and the faith in the future which are so necessary to help build a new prosperity on the ruins of the old. The threats of a great coal, railway and transport strike have been met in the main by means of special negotiations between the Government and the unions concerned and by an emergency commission of enquiry of a novel nature. These special proceedings have been rendered necessary to a considerable extent owing to labour having pushed its claims to the extent of demanding immediate attention. Had labour been prepared to wait, as might reasonably have been expected, until after the conclusion of peace, and had it not introduced a quite artificial urgency, matters might have been dealt with in a more normal way, certainly, in view of the importance of the issues, with less undesirable haste.

Labour may argue that through experience it has learned that only by strikes and threats of strikes has it ever been able to gain attention, and that the comprehensive nature of its latest threat was but a reflex of the more complex organisation and greater solidarity which in recent years it has come to. It may argue that to delay was merely to put off matters indefinitely. There may be something in this. We will not argue the question one way or another. The settlement has been made, and one can but trust that all parties to it will work of their best that it shall prove of good to the country. The settlement, however, is only the settlement of certain claims of certain unions in regard to hours and wages. In a sense it is a parochial settlement. It carries no organisation for the consideration of future differences, and it has no means of extending its provisions to other trades. It is no comprehensive settlement of labour trouble as a whole. Such a settlement as this latter is perhaps too much to hope for in this imperfect world, but it is an ideal towards which one may hope to feel a way.

The idea of dealing with labour unrest as a whole—its causes and prevention—is no new conception nor product of the war, but the war has given it form and a new conscience. Several measures of recent years, such as the Trades Board Act of 1909 and the Industrial Councils of the Whitley scheme, have for their object the dealing with labour in such a way that potential unrest and trouble may be enquired into and, if possible, pacified before they have taken on a kinetic form. The most important move in the direction of an organisation to prevent labour troubles rather than one to deal with them, was made, however, when the Government called together the National Industrial Conference, which met on February 27 last. This conference at its meeting appointed a joint committee consisting of equal numbers of employers and trade union representatives, with a chairman nominated by the Government. The duty of the committee was to report on questions relating to hours, wages, and conditions of employment; the question of unemployment and its prevention; and the question of the best methods of promoting co-operation between capital and labour. This committee published a report last week, which is to be considered at a further meeting of the National Conference to-day. It is possible that the report may be modified in detail by the conference, but improbable that its general tenor will be departed from, and one may anticipate that it will be adopted by the Government, substantially as it stands.

The report is of some length, but its general lines may be briefly indicated. It is stated that time has not permitted a thorough discussion of and investigation into causes of unrest, and it is proposed to submit a statement later. There is, however, an appendix to the report presented by the labour members of the Joint Committee and dealing specifically with this question of unrest. We will refer to this appendix later. The main body of the report is concerned with hours, wages, war-advances, recognition, unemployment, and the institution of a National Industrial Council. It is suggested that a forty-eight hour week should be established by Act of Parliament, that systematic overtime should be discouraged, and that overtime should in no case be paid for at less than time and a quarter. The Secretary of State for Labour would have power to modify the statutory week either up or down for special trades on application by either labour or employers and after suitable enquiry. It will be seen that there is nothing in these proposals in reference to hours which will cause any surprise at the present time. All the same it is possible that considerable modification of the standard week may prove necessary in certain trades. The whole of the discussion on a shorter week, which has now occupied the attention of the country for some time, has centred around important trades of which the working conditions are fairly generally known.

On the question of wages it is recommended that a minimum should be established by legal enactment and should be universally applicable. No specific sum is suggested, but it is proposed that a commission should be appointed to report in three months on the matter. This question will clearly be much more difficult to settle than that of a standard week. It has an international significance and will have to be considered in connection with the International Labour Convention now being discussed in Paris. Before saying more about this, however, we should briefly mention the remaining recommendations of the report of the Joint Committee. The next item after wages on their list of questions was that of war advances. On this point it is recommended that such advances should continue in force for a further period of six months from May 21, 1919, and that a Court of Arbitration should be constituted to enquire into the matter. On the question of recognition it is recommended that employers' organisations should give full and frank recognition to unions as organisations entitled to act and speak on behalf of their members. This is a state of affairs which we have already reached in most trades, but when one comes to the second recommendation under this head—that members should accept the jurisdiction of their respective organisations—we meet an obvious and necessary condition which unfortunately is far from being generally acted on by labour. This is really one of the key matters of the whole labour situation. If a National Industrial Council is able to put this question on a proper working basis and to ensure that labour obeys its own unions and respects its own promises it will justify itself by that alone.

On the difficult matter of unemployment the report has no novel suggestions to make. This is not surprising in view of the brief period in which it has been drawn up, and in view also of the fact that the problem of unemployment goes down to the very basis of organised society. The suggestions of the report are palliatives. They are not cures. The recommendations cover organised short time, limitation of overtime during periods of depression, the placing or withholding of Government contracts in terms of the state of the labour market, and the State development of industry by the institution of afforestation, waste land development, &c. It is also recommended that the present crisis should be

partly met by a comprehensive housing programme. Proceedings such as these, are, of course, all helpful, and many of them have frequently been put into operation. One doubts, however, if periods of slack trade will ever be prevented. The Joint Committee are apparently also to some extent of this opinion, as they suggest existing unemployment benefits should be more adequate and of wider application. They also recommend that advantage should be taken of periods of unemployment, especially in the case of young persons, to improve and continue education.

The final proposal of the report is for the constitution of a permanent National Industrial Council. We need not, at the moment, say much about this. It would consist of 400 members, half representing labour and half the employers. It would meet twice a year and would carry out most of its business by means of a standing committee of 50 members, which would meet at least once a month. The duties of the Council would essentially be advisory, and it would not supersede existing organisations, but clearly if it acted in a business-like way such a council would carry great weight both with the Government and the public, and might ultimately practically control our labour legislation and administration. As the body would equally represent workers and employers it might exercise great influence towards the prevention of labour troubles, and if it is constituted, as probably it will be, we can but wish it all success, and trust we may be able to support it in all its decisions.

Although we spoke of dealing with the main points of the Joint Committee's Report very briefly, we think we have given the gist of their recommendations in reasonable detail, and it will be clear that the general conclusion of the whole matter is that labour is to get more money and work shorter hours. We do not object to this if the arrangement is not going to be one-sided. Labour receiving all these concessions must make a concession in turn if economic stability is to be maintained. The workman is to receive a good day's pay. Is it too much to ask that he should do a good day's work in return, and should be prepared to admit any and every labour-saving device which will increase output? If a man can comfortably work three semi-automatic machines and refuses to work more than one, he is not acting in such a way as to make it ultimately possible to pay the high wages he now asks and is getting. It is particularly in connection with this aspect of industry that one trusts the National Council may do good work. Employers and union representatives meeting frequently together may absorb each more of the other's point of view and may enable us as a nation to raise the status of all our working people, without sacrificing any of our ability to manufacture as cheaply and well as anyone else.

Parallel with this scheme for working towards labour peace at home, we as a nation are taking part in the Labour Congress at Paris, which is aiming at some uniformity of labour conditions throughout the world. The Paris Congress is far yet from having reached the stage of recommending a universal working day, or a universal minimum wage, although these and similar measures are the ultimate ideal. Indeed the details of these matters cannot be discussed until after the formation of an International Labour Office. The present task is the creation of such an office. It is proposed that this office shall have power to bring forward measures somewhat similar to those we have discussed in connection with the Report of the Joint Committee, and that in the case of contracting nations who refuse to carry out the agreements, that the Labour Office shall have power to report to the League of Nations, which then would be prepared to bring economic or other pressure to bear on the offending nation to force it into line. The general scheme aims at bringing labour of all countries on to a mixed council of employers and workpeople, so that some approach to uniform labour conditions may be established throughout the world and so that, as in our National Council, labour and capital may discuss their problems together and may perhaps find a new mutual tolerance.

The difficulties of this project are glaring. The rocks ahead of our National Council are but pebbles compared with the masses the International Council will have to scale. The fixing of a standard working day and a standard wage throughout the world is in our opinion frankly impossible. Were such a thing done either all manufacture would be carried out in old and well-organised countries with skilled workpeople, such as our own, or else newer and partly-developed countries would have to protect themselves with tariffs to such extent that the cost of many necessities would be forced up for them to ruinous heights. Still, although we have no expectation of seeing the universal wage, the International Council may well deal with unfair competition, based on sweated labour, between nations, and may do something to raise the conditions of the workpeople in the more backward countries. Particularly would we welcome it for its educative influence on both employers and employed towards a better understanding of the amazing complexity of the problem they are tackling. After all, the fact that a problem is complex is no reason for failing to attempt to deal with it, and nothing but good should come from the permanent bringing together of employers and workpeople, either in the national or international field.

We have already referred briefly to the labour appendix which is attached to the Joint Committee's Report, and which deals with the present causes of labour unrest. This appendix opens up such wide issues that it is impossible for us to deal adequately with it in this article. The causes of unrest are put down to certain specific matters, many of which are already receiving attention. They include profiteering, unemployment, housing, a shorter working day, &c. In addition to this, however, there are certain paragraphs of which the following is, we think, a fair example: "The increasingly vehement challenge of Labour to the whole structure of capitalist industry as it now exists." This is a grave sentence and covers more than can be cured by conferences between unions and employers. Profit-sharing and co-operation are media which may to some extent meet the claims that lie behind this statement, but clearly the matter goes beyond proposals of this kind and to the very roots of the modern organisation of society. We will not attempt to deal with the question now, but there is a sentence in the appendix which suggests that this feeling is not so widespread among workpeople as its authors apparently suppose. The sentence to which we refer is as follows: "The under-representation of Labour in the present House of Commons must therefore be classed among the economic factors, as well as among the political factors, in unrest." This statement surely stultifies itself. The fact that there are not more Labour members in the present House of Commons is because labour as a whole apparently didn't want more. There were plenty of Labour candidates defeated at the General Election in Labour constituencies, and the only conclusion that can be drawn is that the bulk of labour did not want them. We cannot but think that the authors of the appendix speak for only a small body of labour and not for labour as a whole.

THE STRENGTH AND ELASTICITY OF ELECTRICALLY WELDED JOINTS.

THERE is probably no subject in the engineering world which has attracted so much attention during the past few years as the advances made in the application of electric welding to various forms of structures. Since the introduction of carbon arc welding about thirty years ago, and the modifications due to the invention of the metal electrode some fifteen years later, the very large amount of work which had been done by these systems had been limited to the building up and repairing of the wasted parts in boilers or in parts of the machinery which were not subject to any considerable stresses. It was only when the question of the rapid replacement of ships became vital two or three years ago that attention was seriously drawn to the possibility of securing economic and speedy production by the substitution of welded for riveted joints. Reliable information regarding the properties of such joints was found to be very scarce and to consist almost entirely of records of tests for ultimate strength only.

Ships, in common with most large structures, are subject to considerable variations of stress of an alternating nature, and data regarding the capability of welded joints to withstand such stresses was entirely lacking. Experiments have been carried out under Government auspices both in this country and the United States, but pride of place must be given to the very comprehensive series of tests carried out on behalf of Lloyd's Register of Shipping and described in the paper which has just been before the Institution of Civil Engineers by their Chief Ship Surveyor—Mr. W. S. Abell. There is no doubt that future progress will be very largely influenced by the data just published which covers the whole field in a manner which leaves nothing to be desired. Particularly valuable are the results of the alternating stress tests, as no experiments of this nature had previously been carried out on welded joints.

The first type of apparatus employed for these tests was designed on the same principle as that employed by Wohler in his well-known experiments many years ago. The specimens, which were in the form of round bars, were fixed in the grip of a lathe which revolved at about 1,000 r.p.m., and loads were so arranged that the part of the bar containing the weld was subject to a uniform bending moment of known amount, the stress on each part of the material changing during each revolution from compression to an equal stress in tension. The bars were tested in pairs, one welded and the other unwelded, and the results tend to show that the highest stress at which the welded bars will withstand a very large number of repetitions of alternating stress is about 6½ tons per square inch, as against 10½ tons per square inch in the case of the unwelded bars.

An alternative form of this type of test was also devised in which the specimens used were flat plates 14 in. in length by 5 in. in breadth. The specimens were clamped at the ends while a centre clamp was caused to oscillate and to bend the specimen equally up and down, the maximum total displacement used being ⅛ in. The results obtained corroborate those given by the first method, it being found that the stress at which a flat plate with a butt weld is able to endure a large number of alternations is about 70 per cent. of the stress borne by the similar plain plate.

Closely allied to the foregoing, and indeed in large part responsible for the results obtained, is the crystalline structure of the added material and the structural changes produced in the original steel adjacent to the weld by the heat of the welding.

Special attention has been paid to this investigation and a series of microphotos prepared showing clearly the various constituents of the metal in way of the weld. The deposited metal is seen to be mainly ferrite, all the carbon and manganese of the metal electrode being oxidised away during the process of welding, a result confirmed by the chemical analysis. The junction between the original and the added metal is generally of a very satisfactory nature, the ferrite of the deposited material merging gradually into the normal structure of the adjoining steel. As is to be expected, the crystalline structure of the steel is somewhat altered by the effect of the heat of welding, the grains in the region of the maximum temperature becoming enlarged, but, as the experiments show, not to an extent which seriously depreciates the strength of the steel. In cases in which the added material requires to be deposited in more than one layer, the enlarged grains in way of the first run of welding are modified by the heat of the welding during the deposition of the upper layers, the result being a process of annealing. The microphotos also show clearly that the heating effect is entirely localised, extending for a depth of only ⅛ in. below the surface, and in many cases even less than this.

In the design of large welded structures one of the most important properties of the welded joints is the relative value of their modulus of elasticity as compared with that of mild steel, and in the experiments with which we are now dealing, special attention was paid to the determination of this value. As is well known, the value of Young's Modulus for different qualities of steel varies very little and does not appear to be affected by the

percentage of carbon present. This conclusion is fully borne out by the results of the experiments in which this property of the joints was determined by several different methods of measuring the extension in way of the weld as well as by observations on test pieces composed entirely of deposited material. The ultimate extension of welded joints is, of course, much less than that of ordinary steel, but this is a feature of minor importance since in all cases the calculated structural stresses are kept well within the elastic limit.

Taking a broad line through the results of these tests, it may be said that it has been shown that with careful workmanship, welded joints may be reasonably expected to successfully withstand the stresses experienced by a structure in which the calculated stress does not exceed about 6½ tons per square inch when the stress is of an alternating nature and varies from tension to an equal stress in compression, with possibly a somewhat higher limit when the conditions are less severe. The ultimate strength of the welds is practically always in excess of that of riveted joints, and the elastic properties are quite satisfactory, while the microscopic examination shows that there is no abrupt change in the crystalline structure at the junction of the original and added material. To secure the best results, it is essential that the operators employed should be thoroughly trained, a point which is receiving the attention of firms principally concerned. The possibility of effecting appreciable economy in material is one that must not be overlooked, although the claims of some of the advocates of electric welding are probably unduly optimistic. The new method of construction has certainly come to stay, and, as previously mentioned, these experiments, embracing as they do both static and dynamic tests, as well as careful chemical and microscopic analysis, are by far the most complete and comprehensive yet carried out on the strength of welded joints, and may well mark the beginning of the era of the rivetless structure.

SPECTRUM ANALYSIS AND ATOMIC STRUCTURE.

THE Master of Trinity gave his third lecture on "Spectrum Analysis and its Application to Atomic Structure" at the Royal Institution, on Saturday, March 22. Sir Joseph Thomson began by again referring to the difficulty we had to surmount when explaining the emission of a spectrum by hydrogen, considering that other means of investigation pointed to the conclusion, that the hydrogen atom had one of the simplest structures imaginable and consisted merely of one electron and one positive charge. We might either suppose that the electron occupied one definite position in equilibrium; that would only give us one line in the spectrum. Or we might suppose the electron to circulate round the positive charge in a planetary orbit; on that view we should expect hydrogen to emit a continuous spectrum. So we were placed between Scylla and Charybdis. To surmount the difficulty he had suggested that the electric force between the charges was, at distances comparable with the distances inside the atom, no longer represented by the law of inverse squares, not by u^2 (if u indicated the reciprocal of the distance), but by $u^2\left(\frac{\sin cu}{cu}\right)$, u being large by comparison with c. That force would be periodic and alternately attractive and repulsive, and the electron constituting the negative charge might occupy an infinite series of equilibrium positions, the distances from the centre decreasing in the harmonic progression ½, ⅓, ¼. . . . . as we approached the centre (Fig. 1). Thus the positions would become more and more crowded at small distances and ultimately form an almost continuous streak. Theoretically we should, therefore, have an infinite number of hydrogen atoms, all of the same atomic weight and consequently not separable by diffusion, yet distinct. We should thus be furnished with the potentiality of an infinite number of lines in the hydrogen spectrum; in each position the electron would have a separate period of vibration, and each line would have its source in a different kind of atom.

In the explanatory spectrum diagram (Fig. 2), which Sir Joseph exhibited, the lines marked represented, not the wave-lengths, but their reciprocals, the frequencies, and the horizontal distances between the lines were proportional to the number of vibrations. There were two hydrogen spectra in this diagram. In both cases the lines crowded up towards a boundary on the right (only a few lines being marked) suggesting the appearance of a band which terminated in the extreme lines indicated; further, the lines were grouped in some systematic order, but the grouping was not the same for the two spectra. Balmer had first succeeded in discovering the law of that grouping, and his simple empirical formula had been the starting point of the greatest extension

Fig. 1.

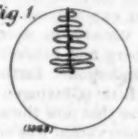
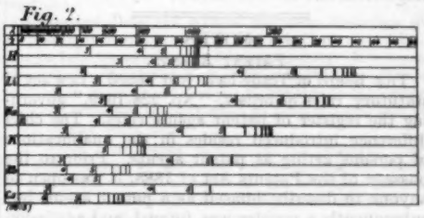


Fig. 2.



that spectroscopy had known. J. J. Balmer's formula (of 1885) for the frequency in the hydrogen spectrum was: Number of vibrations per second $\nu = N\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$, where N was a constant, and m any integer starting from 3 (2 would make the factor zero). The red line in the first hydrogen spectrum corresponded to $m = 3$, the green line to $m = 4$, the next line to $m = 5$, and so on. The more accurate and complete the spectroscopic observations had become in the course of time, the more the validity of the formula had been confirmed. But Balmer's formula only applied to hydrogen, and the extension to the more complicated case of the alkali metals was in the first instance due to the Swedish physicist, F. Rydberg. The difficulty there was that if we took all the lines, a single formula was not applicable; Rydberg had to sort and to separate the lines into series to obtain a formula of the Balmer type for each series. The formula of Rydberg was: Frequency

$$\nu = N\left(\frac{1}{(m+\mu)^2} - \frac{1}{(n+\mu_1)^2}\right).$$

The N there had the same value as in Balmer's formula, a very remarkable fact; the m was constant for each series, the n might be any integer 1, 2, 3 . . ., and μ and μ_1 were fractional numbers smaller than 1.

Looking at Fig. 2 again we noticed three spectra of sodium Na. That in the first row from the top was of the type of the first hydrogen spectrum; the other two represented two different series, but they both had the same limits as indicated by the dotted lines. The first series had been designated the principal series; the other two were called the subordinate series, and were distinguished as the sharp and the diffuse series. Calculating the m and n, we obtained values which corresponded to a vibrating system that, in its simplest form, would be represented by frequency $= N\left(\frac{1}{p^2} - \frac{1}{q^2}\right)$ where p and q were not both integers, being, in the case of the alkali metals, either equal m or $(m + \frac{1}{2})$. The series looked as if disturbed from some simple system, where roughly there were four types of formulæ for the frequency:

(1) $N\left(\frac{1}{m^2} - \frac{1}{(n+\frac{1}{2})^2}\right)$, the sharp series of Rydberg;

(2) $N\left(\frac{1}{(m+\frac{1}{2})^2} - \frac{1}{n^2}\right)$, the principal series;

(3) $N\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$, the diffuse series;

(4) $N\left(\frac{1}{(m+\frac{1}{2})^2} - \frac{1}{(n+\frac{1}{2})^2}\right)$. The first three represented the primary series, the fourth was the secondary series of Rydberg. All the series of an element were interrelated. The series consisted of either doublets or triplets which were repeated in each series. If the lines were disturbed by magnetic forces or electric forces or by pressure, all the lines of the same series were similarly affected

It was further noteworthy that the formulæ gave the frequency itself and not, as in the case of the pendulum laws, the square of the frequency. That indicated that the vibrations could not be of the ordinary pendulum type, as Sir Joseph had explained in the first lecture. The exceptional case was that of a system vibrating under magnetic force; then the frequency was directly proportional to the magnetic force itself. To exemplify what was meant, Sir Joseph sent the discharge through a bulb, from the separately-heated Wehnelt kathode of which a stream of negative particles, glowing in a bluish light, was seen to shoot upward. When a strong magnet was approached, that vertical band of light was seen to curl up, and in a very strong magnetic field each particle would describe a circle. The number of orbits (the frequency of vibrations described in unit time) would be proportional to the magnetic force at that particular point of the field; that implied that the frequency did not diminish as the energy became exhausted and the orbits grew smaller, and in the smaller orbits, therefore, the movements of the electrons must be less rapid, the angular velocities remaining constant. In this way the fundamental condition was fulfilled that the frequency of the vibration was independent of the energy and remained unchanged from the beginning to the end of the light emission.

With the different grouping of the lines in the spectrum the general appearance of the spectrum also varied. Sir Joseph demonstrated this with the aid of an argon tube, bent several times so as to form a kind of flat spiral; the electric discharge passing through the tube produced first a reddish glow; when a Leiden jar was included in the circuit of the induction coil, the colour changed into pale blue; examination of the two spectra, Sir Joseph said, would prove them to be of different types. When the fact that the same substance may give two different spectra had been observed in the case of helium, a controversy had arisen whether the one spectrum belonged to helium and the other to some other substance, possibly an impurity or a modification of helium, for which the name parhelium was proposed. But the two kinds of helium could not be separated from one another by any means, and their identity was no longer questioned. Yet, in a sense, they were distinct; for the substance when giving the one spectrum was not the same as that emitting the other spectrum, the electrons being in different positions. Similarly hydrogen emitted under different conditions two different spectra, each produced by an infinite number of atoms in different conditions. Sir Joseph referred in this connection to what he had said with respect to the absorption spectrum of sodium at the end of the second lecture; the atoms giving the D line were far more numerous than the atoms giving the other lines, and because the D line was produced by a relatively large number of atoms, that line was the most intense. Sir Joseph also gave other demonstrations of the different appearances of discharge tubes under different conditions, and he further showed some characteristic metal spectra, of sodium, magnesium, thallium, iron. The metals were fused in a crucible placed between the carbon electrodes of a horizontal arc, the spectra being thrown on the screen.

Sir Joseph Thomson further added an experiment illustrating in a sense that a body which emitted a certain light would also absorb that light. If we placed a body within an enclosure kept at constant temperature, there would, thermal equilibrium having been established, be as much absorption as emission of radiation. The result would be that there was no difference in the balance, and at constant temperature we should not be able to see anything within that enclosure. Any new-comer, entering the inferno, might hence imagine that

space to be uninhabited. For the demonstration an electric muffle furnace had been heated up to constant temperature; an iron wire, bent to an arc, was introduced into the muffle, and was at first visible in the light coming from the muffle, as a dark arc; within a few minutes the dark image faded, and the wire became quite invisible.

Going back to the atom, Sir Joseph said, he had suggested that, within the atom, the law of the electric force was not the inverse square law, yet that the force increased according to some rule as we approached the centre, and, if so, that the electric force was always accompanied by a magnetic force. The atom might be imagined as a field of electric force, made up of a series of shells alternately of attractive and repulsive forces, the radii of the boundaries of these shells, which represented places at which an electron would be in equilibrium, being in harmonical progression. Superposed on that electric field would be a field of magnetic force, likewise in shells, the boundary of the magnetic field coinciding with a place where the electric force vanished. The electric force would be radial, and that would also be the direction of the magnetic force. How the two forces were interconnected on the basis of the quantum theory, he would discuss in the next lecture. As a rough mechanical illustration of the arrangement we might imagine a line of electric force, with a spin in it, as a physical entity; moving through space and through a field of electricity, the line would cause the electricity itself to spin, and the system would behave like a solenoid. Let now the formula for the electric force previously suggested be written $u^2\left(\frac{\sin 2cu}{2cu}\right)$, substituting $2c$ for c for reasons which would presently become apparent. Let u be equal $1/r$, r being the distance of an electron from the centre of the atom, the radius of which we would call a. When r was great by comparison with c, $\sin 2cu/cu$ would be unity, so that this sine factor would not affect the force at great distances. Inside the atom there would be a series of equilibrium positions the condition of equilibrium being $\sin 2cu = 0$, or $2cu = n\pi$, where n was any integer, or $r = 2cu/n\pi$. If we now remembered that the magnetic force varied as some function of $(a^2 - r^2)$, then, since, for any point in equilibrium at distance r from the centre, $r = 2c/n\pi$, the force would vary as $a^2 - \frac{4c^2}{n^2\pi^2}$ and the frequency ν would therefore vary as this same expression, because the frequency only depended upon the magnetic force at the respective point. Hence ν varied as $a^2 - \frac{4c^2}{n^2\pi^2}$, which might be written: $\frac{c^2}{\pi^2}\left(\frac{a^2\pi}{c^2} - \frac{4}{n^2}\right)$; but this formula was of the Rydberg type, and we had thus an indication of the physical meaning of the Rydberg series formula.

When there was only one electron in the atom, a position of equilibrium would mark a position of that electron at which the electric force due to the positive atom vanished. When more than one electron were present, the position of equilibrium would not correspond to the vanishing of the electric force, but to a position at which the electric force at any electron was balanced by the repulsion due to the other electrons. The position of equilibrium was then no longer given by $\sin 2cu = 0$, or $2cu = n\pi$, but by $2cu = \pi(n + \delta)$, where δ depended upon the repulsion of the electrons. In calculating the various types of line series that might arise, we had to consider that the vanishing condition, $\sin 2cu = 0$, implied either that $\sin cu = 0$, or $cu = n\pi$, or that $\cos cu = 0$, or that $cu = (n + \frac{1}{2})\pi$. We hence obtained two groups of solutions, an even group, which Sir Joseph designated by the letter E, for which $r = 1/n\pi$, and an odd group, designated by the letter O, for which $r = 1/(n + \frac{1}{2})\pi$. In the principal series now the electrons were in the E positions corresponding to $\sin cu = 0$; in the sharp series they were in the odd O position, corresponding to $\cos cu = 0$. If we went back to Fig. 1, where the dots indicated possible equilibrium positions of the electrons, the dots of the E group would alternate with those of the O group.

Now as to the boundary of the atom. The outer boundary of the atom was the place where the magnetic force vanished, and it coincided with a place of electric equilibrium of the electron, at which the electric force likewise vanished. Such a place might coincide with either an even position, or with an odd position of the electron; in the former case the first term of the series formula would be $\frac{1}{(n + \frac{1}{2})^2}$, in the latter case the first term would be $\frac{1}{n^2}$ (going back to the four Rydberg formulæ above given). If any electron were torn off from the atom, the boundary would be disturbed and changed, and that would give rise to a different series of spectrum lines. On this interpretation of the law of force (not the inverse square law) we could imagine an explanation of the sequence of lines and their variety in accordance with the formulæ of Rydberg and others. The formulæ of Rydberg had undergone further improvement, notably by W. Ritz (Göttingen) and by W. M. Hicks (Sheffield), so that now the agreement between calculation and observation was very satisfactory.

NOTES.

PATENT AGENTS.

THE Board of Trade have just issued a new set of statutory rules or orders, "No. 228/1919," governing the register of patent agents rules. The chief difference introduced resides in the qualifications of persons acting as patent agents. Prior to the passage of the Patents Act of 1888, it was open to anyone to describe himself as a patent agent, but subsequently a register was formed, and admission of a name thereto could only be secured either by persons who had been *bona fide* in practice as patent agents in the United Kingdom prior to the Act or by the passing of a certain examination. In recent years this examination has extended over a very wide range of subjects, including, not only the preparation of patent specifications, but the interpretation and criticism of specifications, case law, foreign patent practice and a number of papers have been set in all branches of scientific subjects. Before one could sit for the examination it was essential, either that a preliminary examination had been passed or that one had been in practice with a patent agent for a term of five years. The preliminary examination was one of a series of examinations such as the University Matriculation examinations. According to the new rules, however, both an intermediate examination and a final qualifying examination are to be held and these must be passed before one can be registered as a patent agent. Any person must, in order to be entitled to present himself for the intermediate examination, already have passed one of the preliminary examinations, and in addition have been engaged either as a pupil or technical assistant to one or more registered patent agents for three years. Before one may present himself for the final qualifying examination, he must not only have passed the intermediate examination, but have been engaged as a pupil or technical assistant to one or more registered patent agents for a term of five years. The Chartered Institute of Patent Agents reserves the right, in very exceptional circumstances, to dispense with or modify the conditions and makes some concessions in the case of solicitors.

RAILWAY WAGONS FOR PERISHABLE GOODS.

The interim report of the Refrigerator Cars and Barges Sub-Committee of the Food Investigation Board (Engineering Committee) which has just been issued* by the Department of Scientific and Industrial Research contains some useful suggestions on the design of refrigerator cars. The Sub-Committee points out that so far they have only been able to deal with one section of the reference, namely, refrigerator cars, but they hope to take up the question of barges at a later date. After obtaining particulars of refrigerator cars in service on our railways, examining in detail the cars in actual use, and carrying out a number of experiments the Sub-Committee came to the conclusions that—(1) The insulation of none of the cars is so effective as is desirable, and improvements can be made both in existing cars and especially in cars which have to be constructed in future. (2) The deficiency in the air-tightness of the cars is a serious matter, especially as regards the fitting of the doors. This should be remedied in the existing cars, and proper provision for air-tightness should be made in all those which will be constructed in future. (3) The provision of ice-tanks in the cars may be considered large enough, but the practice of icing them is altogether inefficient, and steps should be taken to ensure improvements on these points. They condemn the present arrangement of dual control by which the railway company provide the refrigerator car, maintain it in running condition and clean it, whilst the owners of the goods load the car and provide the cooling medium. They consider that the whole service should devolve upon only one party, and that preferably the railway company. The Sub-Committee make a number of detail recommendations—firstly, affecting the design and construction of the car, such as the lining, the filling between the linings, the doors, metal fittings and bolts, ventilating louvres and the load on the axles; and secondly, upon the nature of the cooling charge, the position and size of the container for the charge, and state a preference for a portable receiver of a pattern such as the portable foot warmer, containing highly refrigerated calcium brine and placed in the upper part of the car. The report draws attention to the desirability of filling the car with the frozen products in order that the best results may be obtained; they have investigated cases in which 35 per cent. of the car space was vacant. This has a detrimental effect on the goods carried. The report concludes with two suggestions—that thin outer false roofs and sides for sun protection should be provided, and that the cars should be painted white on the outside or whitewashed during the summer. It further states that the Sub-Committee would be pleased to receive from railway companies any designs for refrigerator cars embodying their recommendations.

* By H.M. Stationery Office. Price 3d.

CHEMISTRY IN THE NATIONAL SERVICE.

In the Chemical Society it is the retiring President, not the newly-elected President, who delivers an address. Addressing the annual meeting of the Society on March 27, at the end of his two years of presidency, Sir William J. Pope, F.R.S., of Cambridge, spoke on "Chemistry in the National Service," saying nothing about his own share in the work, to which he partly owes his newly-conferred knighthood. Nearly five years ago, he pointed out, the Department of Explosive Supplies was formed under Lord Moulton. A census of all available chemical products was taken, schemes for their exploitation were laid down, and all materials were approportioned, lest the manufacture of one particular product should create a shortage of raw materials for other equally essential products. While the necessity for utilising all the chemical resources of the country led to efforts of extracting the last possible fraction of efficiency in each component process, the huge production made it profitable to carry out a vast amount of scientific investigation of details of manufacture. At the time of the armistice the country was making yearly about 100,000 tons of nitric acid and sulphur trioxide, 60,000 tons of trinitrotoluene, and 35,000 tons of cordite. The rivalry between two high explosives, picric acid and ammonium nitrate, was an instructive example of the struggle for economy. The ton of picric acid cost 185*l.* to make, T.N.T. 100*l.*, and ammonium nitrate 50*l.* A mixture of the latter two, known as amatol, introduced early in the war by the Research Department at Woolwich, proved more economical to manufacture than the picric acid, and preferable to it; the manufacture of picric acid was hence discontinued last summer and amatol was adopted also in America as standard high explosive and had largely replaced picric acid in Italy and France. Having referred to the efficiency of British gas protection, which called for much skill both in research and manufacture, Professor Pope said that, when in July, 1917, the Germans began to use mustard gas, British technical chemists were amazed to find, from examination of the product, that the compound, dichloroethylene sulphide, was still manufactured in three

stages by the original process of Victor Meyer, with a yield of from 40 per cent. to 60 per cent. of the theoretical. By the end of January, 1918, British chemists had worked out a process which, by the aid of sulphur chloride S_2Cl_2 gave, in the laboratory, 98 per cent. and 99 per cent. of the theoretical yield in one single stage. That process was communicated to the Allies, and at the time of the armistice the Allies had an available daily production of mustard gas equal to the monthly production by the Central Powers. Thus the German chemical service was inefficient, and the scientific chemists under its control were incompetent. Whilst, however, other instances could be given to show that Germany was badly served by her scientific men during the war, it would be difficult to overrate the perseverance and skill displayed by the German chemical manufacturer. The view that this country was superior to Germany in the possession of creative scientific power had always been maintained in modern times by students of philosophy and history, and its correctness had amply been demonstrated during the war. While our nation overcame its initial handicap by a continuous flow of novel scientific devices of military value, our enemies passed through the war with little more in the shape of novel effects than those laboriously worked out during the preceding years of peace. Yet there was little encouragement for those who desired to see pure and applied science flourish in Great Britain, and though it might be long before the scientific industries of Central Europe regained their former predominance, there seemed to be little prospect of sufficient official encouragement being given in this country to scientific and industrial initiative to ensure our position in the competition with other countries, on which the intellectual, artistic and material future of our race would depend. There was every reason to anticipate a re-establishment of the parsimonious treatment of science, and the control of scientific research was again resumed by the lay administrator. Scientific research would have to be assisted by the State, but must be administered by men of scientific training and eminence; otherwise scientific effort would be strangled by red tape.

EXHIBITION OF AERIAL PHOTOGRAPHS.—A number of remarkable photographs illustrating the work of the Royal Air Force are now being exhibited at the Grafton Galleries, Grafton-street, New Bond-street, London, W. An excellent opportunity is thus afforded the general public of obtaining some insight into the work of this, the newest branch of the Services, and of judging to what extent it contributed to the final result. During the war this work had, of necessity, to be kept largely out of sight, especially that of our airships. Some of our readers may, therefore, be surprised to learn that, in the course of the war, these airships travelled nearly 2,250,000 miles engaged in convoying merchant ships, hunting "U" boats, spotting mines, and in operations with the Grand Fleet. The photographs exhibited, which are mostly coloured enlargements, illustrate all branches of this work, and also show nearly every type of airship employed. Of heavier-than-air craft a little more was heard in the brief official reports published referring to aerial operations, but just what was meant by the statement that a certain military objective had been "bombed with good effect" was by no means easy to realise. Examples of the effects, however, can now be seen from the photographic records obtained. One photograph exhibited, showing a direct hit by a bomb on a German ammunition train, illustrates such effects most strikingly. No great military knowledge is necessary to appreciate the importance of photographic reconnaissance work in warfare, but the wealth of detail visible in some of the "mosaic" maps exhibited cannot fail to impress the most casual observer. The value of similar work for rapidly surveying countries, which may be almost inaccessible by other means, will be immediately obvious to the engineer. Many of the photographs illustrate interesting and important military operations on the Western Front, as well as in Italy, Palestine and Mesopotamia. One very remarkable photograph of this class, which was taken in front of Albert on July 25 last, during the British advance, shows quite clearly our men advancing towards the German trenches, through heavy shell fire, over ground thickly pitted with shell holes. The photograph was taken from a height of 10,000 ft. on a 5 in. by 4 in. plate, and the enlargement, we were informed, measures about 18 ft. by 9 ft. Other photographs are of considerable technical interest, and of these we may mention some which illustrate the launching of a large torpedo from a seaplane, and also those of the large rigid airship R. 23 carrying a Sopwith "Camel" aeroplane for attacking enemy aircraft. In conclusion we have no hesitation in saying that every class of visitor will see something of interest at this exhibition, which will remain open until the end of May.

INDUSTRIAL NOTES.

As alluded to in our leader of last week, a settlement has been reached in the railway dispute. The railwaymen's delegates towards the close of the week decided to accept the terms of the Government and rescinded their resolution to strike. The revised terms, as sent out by Mr. J. H. Thomas to the Railway Executive for their consideration previous to the last meeting, are as follow:—

1. *Guaranteed Week.*—The standard week's work to consist of 48 hours. The standard week's wages, exclusive of any payment for overtime or Sunday duty, to be guaranteed to all employés who are available for duty throughout the week, but turns commencing on a Saturday and finishing on a Sunday shall form part of the guaranteed week, and all turns commencing on a Sunday shall be excluded from the operation of the guaranteed week. In the event of a strike affecting the work of any grade, either generally or in any district, the question of suspending the operation of this article shall be referred to the Joint Committee to be set up under Article 7 of this memorandum.

Guaranteed Day.—This is to be further discussed.

2. *Overtime.*—All time worked on weekdays in excess of the standard hours to be paid for at the rate of time and a-quarter, each day to stand by itself for overtime purposes.

3. *Sunday Duty* (12 o'clock midnight Saturday to 12 midnight Sunday).—Time and a-half without addition to rate for overtime and/or night duty. The same to apply to Christmas Day and Good Friday. Hours worked on those days in excess of the standard number of hours shall not be computed as part of the hours of work of any other day.

4. *Night Duty* (week days).—(*a*) All ordinary time worked between 10 p.m. and 4 a.m. to be paid at the rate of time and a quarter. (*b*) All overtime worked between 10 p.m. and 4 a.m. to be paid at an inclusive rate of time and a-half.

5. *Rest.*—In all regular duties a period of 12 hours rest to be shown on the rosters at the home station, but in other cases a minimum of nine hours.

6. *Holidays.*—One week's holiday with pay after 12 month's service, to include casual employés who are regularly employed, without prejudice to those men who already have a longer holiday under their existing conditions of service.

7. *Management.*—The negotiating committees of the two unions will be recognised as the medium for dealing with all questions affecting rates of pay and conditions of service while the present negotiations are proceeding.

A committee shall be appointed to consider and report:—(1) As to the setting up of a joint committee consisting of representatives of the railway Executive Committee and of the two unions to deal with any questions that arise in regard to rates of pay and conditions of service of the men within the conciliation grades as from the date when these negotiations are concluded and the time until some final arrangement is arrived at in regard to the future position of railways. (2) As to the continuance or discontinuance of the existing Conciliation Boards.

When the new Ministry of Ways and Communications is set up it is the intention of the Government to provide in the organisation for, and to avail itself fully of, the advantage of assistance, co-operation, and advice from the workers in the transportation industry.

8. *Wages and Standard Rates of Pay.*—The present wages to be stabilised till December 31, 1919, and any reduction of the war wage under the agreement of November, 1918, to be waived. As regards standardisation of rates of pay and removal of present anomalies, this can only be dealt with in connection with a general revision of permanent wages, and, therefore, it is proposed that the present negotiations shall be continued for fixing new standard rates, so as to insure that all men throughout the country shall receive the same payment for same work under the same conditions. This will involve a transfer of a part of the war wage to the permanent wage, but the Government agrees that up to December 31, 1919, no man shall receive less in weekly rate of wage, plus war wage, than he is receiving at present, while anyone to whom the new war wage and new rate yield more than they are receiving at present, shall receive the advantage as soon as an arrangement is arrived at. At the end of the year the whole situation will be reviewed. The war wage will have to be looked at in the light of the circumstances of the time generally, and it will be open to the men to ask for a revision of the new standard rates if they think a case can be made for it. But the anomalies of varying pay for similar work under similar conditions will have been removed, and future negotiations will be rendered much easier through their being only one set of figures to work upon.

9. *Other Items in the Programme.*—These to be discussed at further meetings.

The report adopted unanimously by the Provisional Joint Committee appointed by the National Industrial Conference (see page 317 *ante*), was issued last week. The chairman is Sir Thomas Munro, K.B.E., and the secretary Mr. C. S. Hurst, of the Ministry of Labour. The report deals with the hours of labour per week, the maximum being fixed at 48, with overtime; minimum time-rates of wages. It also covers the methods of negotiation between employers and trade unions, unemployment, &c. The report is to be considered at a further meeting of the Conference to be held to-day in the Central Hall, Westminster. We deal with this report in our leading article, page 441.

At the twenty-fifth annual general meeting of the shareholders of Messrs. Lever Brothers, Limited, held at Port Sunlight, on Thursday, March 27, Lord Leverhulme referred to the firm's scheme for a 36-hour week. The scheme was ready to be put in operation as soon as the necessary arrangements could be carried out. It provided for two shifts, each of 36 hours per week, the morning shift to work 6 days from 7 a.m. to 3.45 and from 9 to 1.15 p.m. The afternoon shift is to work 4 days from 1.15 to 4.45 and from 5.15 to 9 p.m., and on Friday to 8.45 p.m. instead of 9 p.m. The shifts are to alternate every week.

The wages under the new system were to be exactly the same for 36 hours as they had been for 48 hours in the past. This was obviously an essential, and it was equally certain that by proper organisation the staff could accomplish the work without adding any expense to the company, and therefore no cost would be added to the product or to the management of the business.

A most interesting development in regard to the method of paying the men's wages was outlined by Lord Leverhulme at the same meeting. Instead of the men crowding round the pay office at the week-end, arrangements were being made to open a banking account for each man at the bank nearest his house, and his account would be credited weekly with the wages to which he was entitled. He would thus be able to draw what he required for household purposes, and anything left in would receive bank interest, supplemented by interest granted by the firm to bring it up to 5 per cent. Not only would the tendency be to help the workmen to save, but this departure would also have the effect of raising the men's position and dignity.

According to the daily press, contracts for 750,000 tons of steel rails required for reconstruction in Northern France were recently offered to English and American manufacturers. When the English manufacturers got down to absolute bare net cost, with no profit at all, they were still 30s. per ton outside the price quoted by the American manufacturers. Orders for the first 500,000 tons have already gone to America. The remaining 250,000 tons were held over for English manufacturers, but the latter could make no certain promise of delivery owing to threats of strikes, and if they have not already gone they are likely to follow the first 500,000 to America.

An order of about 375,000*l.* for locomotives was offered to the North British Locomotive Company. This is believed, also, to have been lost to America. It is a matter of common knowledge in the iron and steel and engineering industries that reconstruction orders for France and Belgium are going to America far more than they are coming to this country, although British manufacturers want the work.

Mr. A. J. Hobson, of Sheffield, the chairman of several of the largest steel-making concerns in the Northern Counties, whose expert knowledge of industry and industrial finance led to his appointment on the Advisory Committee of the Board of Trade and who gave evidence at the recent Coal Commission, is reported to have said that "without a larger and cheaper production, home and export trade will be crippled. We can only carry on in hand-to-mouth fashion. Contract prices for big work in England and abroad cannot be successfully quoted because values are excessively high and deliveries problematic."

The annual meeting of the Birmingham Chamber of Commerce was held last Monday, when Mr. H. W. Sambidge, the president, in moving the adoption of the annual report, said every country was crying out for supplies, and Great Britain was never in a better position for mass production than she was at the present time. The only hampering factors were those of uncertainty as to the industrial position and future, doubt as to the prices of raw materials, insufficient means of transport, and fear as to the continuance of the present high taxation of industry.

All sorts of demands were being made by workers for increased wages and reduced hours of labour, due mainly to the belief that organised bodies of workpeople had only to be sufficiently determined to get whatever they demanded, in the ignorant belief that the resources of the State, or of the commerce of the

country, were inexhaustible. It should be remembered there were economic limits, which, if passed, would counteract the temporary advantages which might be obtained by mere increased rates of wages and shorter hours of work. There was also a very serious danger if, out of sympathy, or as a result of determined pressure, all demands were conceded; but perhaps the greatest danger of all was that the Government might be tempted to launch great experimental schemes of State Socialism, which might tend to the destruction of healthy competition, to an enormous growth of officialism—of which they already had too much—to national waste and extravagance, and consequently to increased cost of production.

Sir Norman Hill delivered an address in Liverpool on Monday last, "On Shipping in its Relation to Commerce," at a meeting of the Liverpool and District Bankers' Institute, when he urged that we had now in this country to get back to real trading if we, as a nation, were to keep out of the bankruptcy court, and as we got back to real trading we should be met with the old problem of what should be the relation of shipping to commerce. He submitted:—

1. That the ships are made for the cargoes, and not the cargoes for the ships. He believed that any attempt to use the carrying power of the ships for the purpose of diverting, limiting, directing, or controlling the flow of commerce, would end in disaster. Let commerce follow its business course, and let the carrying power of the ships be used to serve its needs as they arose.

2. That if commerce is not to be controlled by shipping, then the carrying power of the ship must be sold, like any other commodity, to the highest bidder.

3. That the position of Great Britain as the great sea carrier of the world can only be maintained by private enterprise.

The State could not provide any form of control capable of satisfying the constantly varying demands for tonnage. The intervention of the State in what was essentially an international trade would be regarded as a challenge by other nations, and thereby our hold on that trade would be imperilled. The life and spirit of both commerce and shipping was surely freedom. If our overseas commerce were placed under State control, either directly or by means of the uses to which the carrying power of our ships were put, he was convinced that we should never attain our hopes and ambitions, and that we should be overwhelmed by the burden of our debt. But if we relied, as we had done in the past, on our own individual efforts, and each of us did his utmost, he was equally convinced that we should be able to carry the burden of our debt, and to build up a stronger, happier, and better nation.

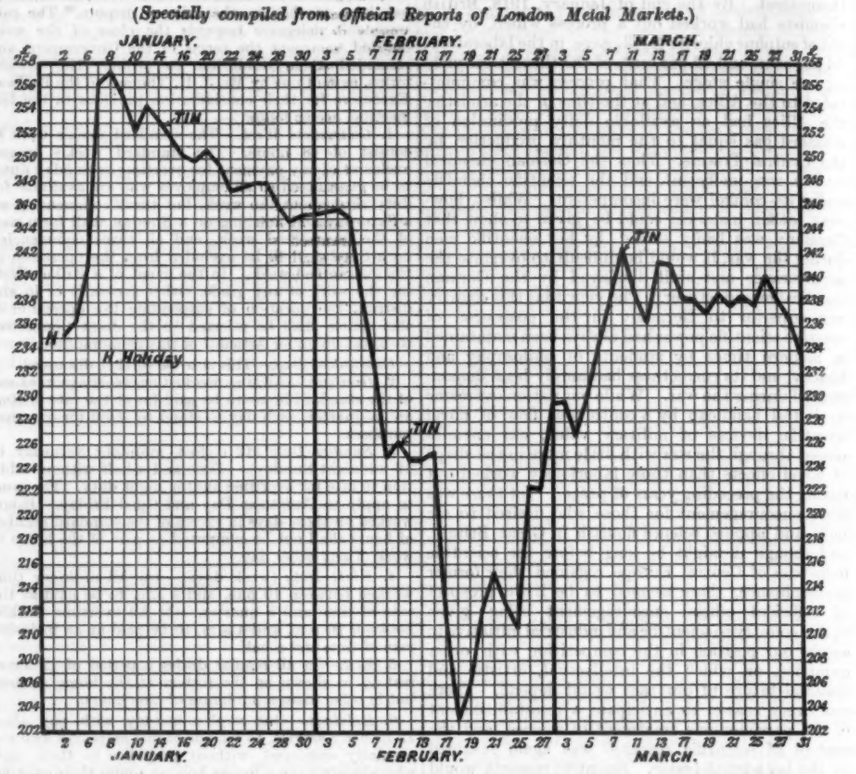
In the course of his speech at the annual meeting of shareholders of Hadfield's, Limited, held in Sheffield last Friday, Sir Robert Hadfield, Bart., dealing with the relations between capital and labour, said they had heard a great deal lately about the shop stewards who represented one of the new phases in the labour question. Provided they did not run counter to their respective unions' rules and regulations, he saw no objection to their formation. Whilst at first sight their existence as a body might seem but another load to the heavy burden already borne by those who had to be engaged in the actual management and running of the industrial machine, yet, if wisely used, he thought the shop stewards' movements would in the end be productive of benefit. He met a deputation of shop stewards in his own company's works, and found them in no way unreasonable. The result of the meeting was a pleasant surprise. It was particularly pleasant to regard the friendly feeling between themselves, and the various departments of employees in their large works. Although, added Sir Robert, they occasionally "chipped" out, in the end they generally managed to come to some satisfactory arrangement.

With regard to the future, Sir Robert said he was not a pessimist, but an optimist. We were quite prepared to face free and fair competition. German competition was not fair, because of the bounty system, and all kinds of low-down tricks. We did not care for that kind of business, but we did not mind what our American cousins did. If they helped to smarten us up, that was all the better. He had visited America, and knew it pretty well, and he did not think we had anything to fear from America. She was going to keep us up to the mark, and that was a good thing.

FEDERATION OF BRITISH INDUSTRIES.—The following resolution was passed by the Federation of British Industries at a meeting of its Executive Council on Wednesday, March 26: "That every effort should be made by the Government to deal with purely British firms in preference to firms of alien origin, and that in pursuance of the Government's policy it is not sufficient for the Government to close down firms which are technically of enemy origin, but that it must set an example by placing its contracts exclusively with firms owned and controlled by British subjects."

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig-iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. (For official regulations see page 45, vol. cii.) A new series of prices for iron and steel has been issued, and appeared on page 646 of our issue of December 6, and on page 23 of our issue of January 3. The Minister of Munitions has also issued certain regulations controlling the prices and dealings in non-ferrous metals; these restrictions were removed on December 17.

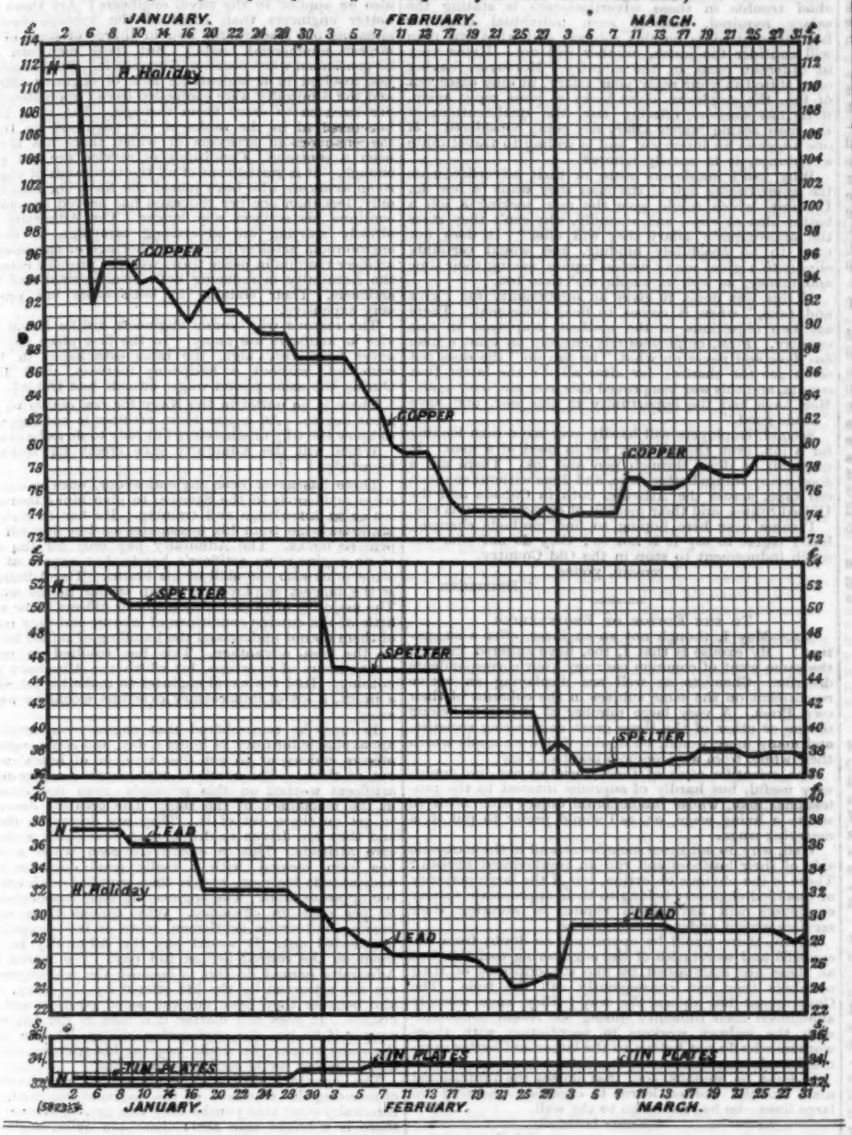
"THE SHIPYARD."—Messrs. Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne, issued on February 15 the first number of their new magazine, *The Shipyard*, the object of which is to help in bringing together the many interests in the different yards and works controlled by the firm on the Tyne and Wear. It contains 16 pages of matter which will greatly appeal to every member of the firm's different establishments. Among its notable features is its handy size, it measures 9¼ in. by 7 in., its price of 1*d.* only, and the complete absence of advertisements. Advertisements for all kinds of local produce in other works' magazines seem to us greatly to detract from the value of the publications, and are not liable to increase in any marked degree the trade of the advertisers.

THE COMMERCIAL MOTOR USERS ASSOCIATION (INCORPORATED).—The annual general meeting of this Association was held at the Savoy Hotel, London, W.C., on the 2nd inst. In the Annual Report which was presented at that meeting it is stated that the "Reconstruction Plans" of the Association cover among other things pressure for the abandonment at the earliest possible moment of petrol licensing and other control measures due to the war, to secure the adoption of standard specification for petrol, benzol, &c., to develop home fuels and their use free of Excise Duty, the application of proceeds of motor taxes to road improvement, and the requirement that all road users should conform to adequate lighting regulations. The Report also states that various recommendations of the Association had been adopted by the Local Government Board Committee on road locomotives. These recommendations include that the maximum unladen weight of a heavy motor car may be increased from 5 to 6 tons and of a trailer from 1½ to 2 tons; the speed of a heavy car drawing a trailer, if both have rubber tyres, may be increased from 5 to 8 m.p.h.; that the definition of laden weight should not be amended to include water and fuel; and that the demands of certain road surveyors for the compulsory use of large-diameter wheels should not be conceded. It was also reported in connection with the sale of Government lorries that future sales should be more widely advertised and that some thousands of practically new three-tonners will shortly be offered by makes instead of in odd lots. The annual luncheon was held before the general meeting, when some 250 members and friends attended.

GOVERNMENT ORDERS AND STATISTICS.—*High-speed Tool Steel and Scrap therefrom:* With reference to the Steel Supplies (Partial Suspension) Order, 1919, the Ministry of Munitions has given notice that after the date of that Order all dealings in high-speed tool steel and scrap therefrom are unrestricted, and consequently the maximum prices applicable to these materials cease to be operative. *Surplus Railway Material:* The Ministry of Munitions has given notice that the following items of railway material are at present available for disposal:—75-lb. rails, light track, locomotives of various types, tractors, trucks, trolleys and other material. Proposals are accordingly invited. Enquiries should be addressed to "The Controller, Disposal Board, Railway Materials Section, Armament Buildings, Whitehall Place, S.W. 1." *Cold Blast Pig-iron:* The Minister of Munitions states that in consequence of an arrangement with the manufacturers whereby certain existing subsidies payable on cold blast pig-iron have been or are to be withdrawn, he authorises an advance of 11*s.* per ton in the maximum price to take effect on and after April 1, 1919. This advance added to the increase of 15*s.* which took effect on January 1, will raise the maximum price for home sales to 10*l.* 8*s.* 6*d.* per ton, f.o.t., makers' works. The export price remains unchanged at 11*l.* 12*s.* 6*d.* per ton, but the export drawback will be reduced by the amount of the increase in the home price. *Output and Stocks of Iron and Steel:* The following figures are issued by the Minister of Munitions. The total stocks in the hands of the Government available for disposal on March 15, 1919, were as follows: Pig-iron (Swedish), 80,000 tons; shell steel billets (suitable for re-rolling) in United Kingdom, 75,000 tons; in United States of America (to be shipped if unsold under liquidation), 70,000 tons; steel in various forms, billets, blooms and scrap in Canada (to be shipped if unsold under liquidation), 163,000 tons; bright steel, 5,000 tons; bar iron (Swedish), 10,000 tons.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



PERSONAL.—Messrs. John Kirkaldy, Limited, 101, Leadenhall-street, E.C., announce with the deepest regret the death of Mr. T. J. Walford, who was secretary of the company for the last twenty years. Mr. E. J. Corpe has been appointed secretary in his place.

THE LATE MR. JAMES WATSON.—We regret to have to announce the death which occurred suddenly in London, on March 29, of Mr. James Watson, the waterworks engineer for the city of Bradford. Mr. Watson entered the Institution of Civil Engineers as an Associate in May, 1875, and was made a full member of that Institution in January, 1885. He was 75 years of age at the time of his death, and was, we believe, one of the oldest waterworks engineers in the country. Mr. Watson was born at Douglas, South Lanarkshire, on March 18, 1844, and after his schooling, was articled, in 1860, to an architect and surveyor of his native town. He remained as the architect and surveyor's assistant from 1864 to 1867, when he established a practice of his own in Lanark. Two years later, he was appointed chief assistant in the office of the burgh engineer, Dundee, where he had a considerable share in the planning of Dundee. In 1871, he was nominated engineer by the Dundee Water Commissioners. Mr. Watson was appointed to his position at Bradford in 1891, a position in which he carried out a considerable amount of original work for supplying the city with potable water. He was very frequently consulted, not only on water supply and distribution schemes, but also on numerous other civil engineering projects, such as sewage and other problems. His services as a consultant and expert witness were also often called upon by authorities in this country and abroad.

AMERICAN WOODEN SHIPBUILDING.—We read in *The Times*, that plans for discontinuing the Government's war venture in wooden ships were laid at a conference of United States Shipping Board officials and representatives of 34 shipyards in 13 States of the Atlantic coast and the Gulf of Mexico. Reasonable concessions as to payment of claims for investments in yards and for cancelled contracts were promised by Chairman Hurley and prompt settlement was assured. Claims for losses due to the creation, as a war measure, of shipyards which now will be scrapped as worthless are expected to aggregate a maximum of 600,000*l*. More than 20,000,000*l*. in contracts have been cancelled, but in many instances the work had not begun, so the amount to be paid by the Government is correspondingly less. Shipbuilders declared that the decision of the Shipping Board to confine construction to steel vessels meant that at least 90 per cent. of the facilities for building wooden ships would be rendered useless in the future. Vessels now on the ways are not to be completed, and orders have been given to finish only hulls which can be used as barges. According to figures given at the meeting, there are now 170 wooden ships for which machinery is unavailable. They will be utilised as covered barges and sailing schooners. Builders admitted that wooden ships could not compete with steel vessels in general trade, and the demand for barges now apparently is more than met. Possible building for foreign account, which now is prohibited, was not discussed as an alternative for closing the yards. It will be noticed that no mention is made in the message of the wooden shipyards on the Pacific Coast. Many wooden shipyards were built during the war in the neighbourhood of Portland, Oregon, and Tacoma, Washington, where large supplies of lumber were available.

IRON AND STEEL INSTITUTE.

A GENERAL meeting of the Iron and Steel Institute will be held on Thursday, May 8, at 10.30 a.m., when the council will present their report for the year 1918. The hon. treasurer will present the statement of accounts for 1918. The award of the Bessemer medal for 1919 to Professor Cav. Federico Giolitti, Ph.D., of Turin, will then follow, when papers Nos. 6, 8, 3, 16, 17, will be read and discussed. At 2.30 p.m. a joint session (by invitation of the Institution of Electrical Engineers) will be held to discuss papers on electric steel furnaces. The following is a list of the papers likely to be submitted: "Developments in Iron and Steel Electric Furnaces," by Mr. J. Bibby; "The Booth Hall Electric Furnace," by Mr. W. K. Booth; "The Development of the Electric Melting Furnace," by Mr. D. C. Campbell; "The Control of Electric Arc Furnaces," by Mr. H. Coates; "New Type of Electric Furnace," by Mr. Axel Sahlin; "Large Electric Furnaces," by Mr. Victor Stobie. On Friday, May 9, at 10 a.m., a general meeting of members will also be held, when the award of grants from the Andrew Carnegie Research Fund in aid of research work will be announced, and papers Nos. 11, 10, 1, 2, will be read and discussed. An afternoon session, on Friday, will commence at 2.30 p.m., to read and discuss papers Nos. 15, 7 and 12. The following is the list of papers that are expected to be submitted: (1) Mr. J. H. Andrew, "Manufacture and Working of High-Speed Steel"; (2) Mr. J. O. Arnold and Mr. F. Ibbotson, "Molecular Constitutions of High-Speed Tool Steel, and their Correlations with Lathe Efficiencies"; (3) Mr. C. H. F. Bagley, "Modern Steel Metallurgy"; (4) Mr. G. Cesaro, "Note on the Liquidus in the Iron-Carbon Diagram"; (5) Mr. G. Watson Gray, "Estimation of Phosphorus in the Presence of Tungsten"; (6) Mr. L. Greiner, "Report on the Condition of Belgian Iron and Steel Work after the German Occupation"; (7) Mr. D. Hanson and Mr. J. E. Hurst, "Improvements in the Case-Hardening Process"; (8) Mr. L. C. Harvey, "Use of Powdered Coal"; (9) Mr. K. Honda, "On the Non-Allotropic Nature of the A2 Transformation in Iron"; (10) Mr. J. C. W. Humfrey, "Macro Etching and Printing"; (11) Mr. H. M. Howe, "A Review of Work of United States National Research Council"; (12) Mr. A. McCance, "Carburisation of Iron at Low Temperatures"; (13) Mr. A. M. Portevin and Mr. M. Garvin, "An Experimental Investigation of the Influence of the Rate of Cooling on the Hardening of Carbon Steels"; (14) Mr. K. Tawara and Mr. G. Asahara, "On Graphitisation in Iron-Carbon Alloys"; (15) Mr. G. Taylor, "Some Points in the Manufacture of Files"; (16) Mr. J. H. Whiteley and Mr. A. F. Hallimond, "The Acid Hearth and Slag"; (17) Mr. B. Yanecke, "Deoxidation, and the Influence of Lime on Equilibrium in the Acid Open-Hearth Furnace." In celebration of the Jubilee of the foundation of the Iron and Steel Institute in 1869, the annual dinner will be held this year at the Guildhall, London, by kind permission of the City Corporation. The price of the tickets is 2*l*. 12*s*. 6*d*. each. The autumn meeting will be held on Thursday and Friday, September 18 and 19, 1919, in the rooms of the Institution of Civil Engineers, Great George-street, London, S.W. 1.

TIMBER SUPPLIES.—The Board of Trade announce that in view of the shortage of yellow pine in this country, the Controller of Timber Supplies has taken steps to procure a quantity for early delivery, totalling 23,197 standards.

BUSINESS TRAINING FOR ENGINEERS: BRISTOL UNIVERSITY.—In the university courses for training engineers in the United States and Germany a certain amount of business training is given, with a result that in these countries there are many more engineers directing and administering engineering concerns than is the case of Great Britain. At the suggestion of the Dean of the Faculty of Engineering of the University of Bristol (Dr. Wertheimer), the Senate has decided that in future the curriculum for the B.Sc. Degree shall include attendance at a course dealing with book-keeping, methods of administering and organising works, elements of commercial law, depreciation, estimating, costing and writing of specifications. It is expected that this will lead to engineering graduates of the University obtaining in the future even still more responsible posts than those which their predecessors held.

THE LATE SIR THOMAS MITCHELL.—We regret to have to announce the death, on Monday evening, at his residence, Southsea, of Sir Thomas Mitchell, late Chief Constructor at Portsmouth Dockyard, where he had charge of the building of the first Dreadnought. Sir Thomas was born in Belfast in 1844; he entered the Admiralty service as a shipwright apprentice at the Chatham Dockyard, and passed through the various shops, being ultimately made a foreman, in which capacity he was sent to Portsmouth Dockyard where he was engaged in the building of the battleship Trafalgar, among other units for the Fleet. At a subsequent period, he acted as Admiralty overseer at Messrs. Palmers' works, Jarrow, and also served as Naval Constructor at Hong Kong Dockyard, and as Chief Constructor at Devonport, Bermuda, Sheerness and Chatham. From Chatham, he was selected by Admiral Sir John Fisher, to take in hand the building of the first Dreadnought, which led to his transference to Portsmouth Dockyard; under Sir Thomas' supervision, the Dreadnought was completed for trial one year exactly after the first laying of the keel. In recognition of his services, Sir Thomas had the Companionship of the Victorian Order conferred upon him in 1906, and was knighted in 1907, the year in which he retired. Our regret at his death will be shared by a wide circle of shipbuilders and engineers.

THE COAL DEPOSITS OF THE SAAR DISTRICT.

THE fate of the Saar district is naturally being watched with keen interest in France owing to the important coal deposits it contains, France being in great need of this commodity.

The coal basin in question, which is almost exclusively Prussian State property, covers an area of about 110,000 hectares. To the north of Saarbrücken it extends into Pfalz and Rhenish Prussia. At the Geological Congress in Toronto in 1913 the Saar coal deposits were estimated to contain 9,769,000,000 tons to a depth of 1,200 m. The output prior to the war was intentionally kept at a low figure, neither the Prussian nor the Bavarian Governments being desirous of creating unnecessary competition with the Westphalian coal industry. The annual output, however, did somewhat increase, rising from 10,067,000 tons to 13,000,000 tons. This comparatively moderate production was due entirely to restriction and not to any technical difficulties or to any lack of coal.

A few figures will show the advantage that would accrue to France from the possession of the Saar coal mining district. France's consumption of coal in 1913, according to official statistics, amounted to 64,834,000 tons, of which total 40,045,420 tons were produced within the country, while 24,788,580 tons had to be imported from abroad, and these figures were steadily rising. In spite of France's large imports of coal, the country was able to smelt only about half the quantity of iron ore produced, inasmuch as out of a production of 20,917,870 tons of ore in the year 1913 8,656,000 tons were exported, 4,254,000 tons going to Belgium and 3,810,000 tons to Germany.

The cession of Lorraine to France will about double that country's output of iron ore, Lorraine having produced 21,136,000 tons in 1913. This ore was distributed as follows:—

11,177,000	tons to	Lorraine (then German).
2,612,000	,,	Saar district.
2,910,000	,,	Westphalia.
3,500,000	,,	Luxemburg.
237,000	,,	Belgium.
500,000	,,	France.

The iron works in Saarbrücken and in that part of Lorraine now to be ceded required about 4,500,000 tons of coke for smelting this ore and the Saar coal mines supplied about half of this coke. In addition they supplied practically the whole requirements of the works in French Lorraine, a total of 2,355,000 tons being imported during 1913. That year's production amounted to 13,000,000 tons, and of this quantity the collieries themselves used 1,407,000 tons for the production of coke. The iron and steel industry accounted for a further 3,965,000 tons.

Not only would the Saar coal mines prove a great boon to the French iron industry, but the district also contains a number of large iron works on the river Saar. Among them are the Brebach works, which before the war had five blastfurnaces, with a daily production of 500 tons; the Burbach works, with eight blastfurnaces and a daily production of 1,200 tons; and the works at Volklingen, with seven blastfurnaces and a daily production of 1,000 tons. The works at Hostenbach, also included, specialise in the manufacture of steel, as also do the works at Bous, which is equipped with electric steel furnaces. The works at Dillingen also had four blastfurnaces and a daily production of 800 tons, while east of Saarbrücken lie the works at Neukirchen with five blastfurnaces and a production of 800 tons a day. These figures apply to the time before the war, and during the last five years a large number of coke furnaces and many Martin and electric furnaces have been added to the plant then in use.

Whilst the "German" Lorraine in 1913 produced 4,165,498 tons of iron and 2,286,354 tons of steel by means of coal from the Saar basin, the works in the Saar valley produced 1,374,544 tons of iron and 2,079,625 tons of steel mostly from ores coming from Lorraine. The two districts consequently supplement each other, and their severance would prove very harmful from an industrial point of view.

Should France obtain possession of the Saar district, her eastern corner would become a singularly important centre of the iron industry in view of the fact that French Lorraine itself has a production of 3,493,000 tons of iron and 2,256,000 tons of steel. Luxemburg's production of 2,548,000 tons of iron and 1,136,000 tons of steel may possibly be added to this since Luxemburg has already terminated her connection with the German customs union.

SITUATIONS VACANT.

TO THE EDITOR OF ENGINEERING.

SIR,—Having read with interest the two letters of last week's issue in connection with the above subject, I would like to say the following: Having just returned from the western part of Canada and the States, where I have been the last seven years, I find that the methods employed in advertising for men in the engineering trade are just as crude as they were when I left this country; they are nearly all after the same pattern; "wanted so and so, state age, experience, and salary." The chief trouble in these advertisements is stating the salary required, because each individual employer has different ideas on this subject, and what one man will consider too much, another will not. Rates vary in different parts of the country. Moreover, having once stated in your reply your salary, in nine cases out of ten, the employer never looks at your reply again, if he has someone offering less, the qualifications of the man asking higher salary not being considered. If one suggests an interview, and is willing to travel quite a distance, it is usually ignored.

Why can't employers state in their advertisements the approximate age of the man they want (a few do, I admit) which would give the man seeking a job a better idea at once, and secondly, why can't they state the approximate salary they will offer? It does not need to be absolutely binding, and would certainly eliminate a great many useless replies, saving their time and money, as well as employees' time too.

If this was done, it gives an opportunity for "give and take," when it comes to final settlement. There are two objections to the methods employed in this country. First, employers rely entirely on what a man *has done* and never on what "he can do" (he does not often get the chance), for after all it's the latter that counts, and this war has proved this over and over again. Men have had the opportunity in this war, and have "made good."

Second, employers will hardly ever see a man looking for a job, even though they are in need of a man. It must all be done through pen and ink. There are a good many things better done, and done without so much red tape, across the Atlantic, both in Canada and the United States, and their method of engaging men is one.

I came over here hoping to find methods changed, but I regret to say it is not so; they do not offer one much inducement to stop in the Old Country.

I remain, yours,

"BRITISHER."

TO THE EDITOR OF ENGINEERING.

SIR,—May I, though not an engineer, offer a suggestion? My excuse is that I, too, have suffered through the same want of common courtesy your correspondents describe. Chemists as well are displaying an active resentment on the same subject in the columns of their own Press. A very large number of engineers belong to one or other of the three great engineering societies, and many more would, no doubt, if it were made worth their while, from an economic point of view.

The scientific aims of these societies are, no doubt, very useful, but hardly of supreme interest to the professional man, whose fundamental object after all is to secure a living wage, or, as I would prefer to put it, a marrying wage.

Well, why do not these societies attend to the economic side of their business and run an employment bureau? There is the obvious objection, but if the large majority of qualified engineers belong to their appropriate society employers will have little chance of securing their services except under fair conditions.

Again, there would be opposition no doubt from the councils and secretaries of the engineering societies, but as these are maintained by the subscriptions of their members they can consequently call the tune. The Government has shown the way; they have recently announced their difficulty during the recent conference with the railway workers in negotiating with those workers who do not belong to the larger and better organised trade unions.

It must be obvious, too, that unless the professional man, like the worker, learns to organise—and that on large lines—he has got to go to the wall.

Yours faithfully,

"A CHEMIST."

Chester, March 31, 1919.

NAVAL ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—With further reference to the correspondence now going on in your columns on the subject of "Naval Engineers," there is still a few points I would like to add. "An Engineer" is quite right in describing the Admiralty programme regarding the training of their engineers as hopeless. The engineering branch of the Royal Navy has always been kept in an obscure place. The traditions of "Nelson's Navy" die hard; there are still some "last ditches" executive officers who look upon engineers as upstarts and necessary evils. When it is remembered that the whole of a modern warship is the product of engineering brains, however, it is time old-fashioned prejudices were wiped away. The Admiralty never have been able to obtain sufficient numbers of engineers or of engine-room artificers. The reasons are not far to seek. On attempting to join the Navy as an engineer, it is not a question of what are your abilities, what are your qualifications, but rather what is your social position. In other words, the attempt is to make gentlemen engineers in the same way that other officers are obtained for both Navy and Army. The Admiralty attempt to find engineers by getting men of independent means to take up naval engineering as an interesting hobby. Engineering as anything else but a hobby does not appeal to this class of officer.

To-day the result is shown, inasmuch that the engineer officer is a man usually depending on his pay for his living, proving that it is only the comparatively poorer cadet who will go for the engineering branch, and he is looked down upon by his brother officers as only something belonging to the greasy black brigade. Why not split the two classes, letting the engineering branch stand alone. All the chief engineers of the Merchant Service have risen from the bottom—why cannot this also be applied to the naval engineers? Are there any better engineers than some of the tobacco-chewing, swearing old blackguards now in charge of some of our largest commercial boats? But these men can also be gentlemen when occasion demands it. Pure snobbery has resulted in a lamentable lack of engineer officers, and the Admiralty were compelled to call upon Merchant Service men to carry them through. The same thing has occurred in the ranks of the engineers by trade, the engine-room artificers of which there has always been a shortage. Conditions of service are not good enough. It is stated that of all the thousands of engine-room artificers who have joined the Navy for hostilities only, less than one per thousand has proved anxious to continue his services any longer. The Admiralty are already starting an advertising campaign to obtain engine-room artificer recruits. Shortage of engine-room artificer recruits in peace times was the primary cause of the Admiralty introducing both mechanicians and boy artificers. Their training in both cases has proved very expensive.

The reasons why young engineers dislike Naval service as artificers are many. In the first place pay has never been very high, the rates established in 1868 remained, without a halfpenny increase, until 1918. During the same period wages outside had trebled.

There is no outlet in the Navy for *real ability* to any great degree. An engine-room artificer is not supposed to know the why or wherefore but only to do as he is told.

When will the Admiralty give credit for technical knowledge?

There has never been any endeavour, once an engine-room artificer is in the Service, to give him a thorough sea-going knowledge and training. He has to pick up his knowledge from his messmates or buy himself expensive books. The Admiralty pay only for the skill of an engine-room artificer's hands, but expect at the same price also the skill of his brains. The Admiralty is the biggest employer of cheap labour in the world. The majority of present-day engineer officers know very little of the outside conditions of labour, and very many of them do not understand the handling of skilled labour to the best advantage. This has resulted in many weary hours of overtime, for which the Admiralty pay nothing. Had the naval engineer to make his job show a profit, a lot of unnecessary overtime would be wiped away.

It must be remembered that engine-room artificers are available for duty 24 hours a day, and some engineer officers endeavour to get that number of hours' work out of them. The result is soon shown: engine-room artificers worked on this principle soon lose interest in the machinery of the ship. The greatest desire is to get on shore out of it. They are driven on shore, and they are driven to drink, soon developing a don't-care attitude. This is effectively seen when a ship has been blessed with a really good engineer who understands his man, and is then supplied with one of the opposite kind. The engineering staff has decreased 50 per cent. in efficiency. Why cannot these overbearing, autocratic gentlemen, more or less competent, be weeded out. It would pay the Admiralty to put them on the retired list on full pay. The reason the Admiralty cannot do this is because the real engineers are not attracted by the life offered by the Navy, and also because they have not the social position and influence. It does not matter if a man is the son of a pauper if he has the engineering ability, let him have the same chance, he would pay for his training, which many present naval engineers have not.

The lamentable shortage of engineers has been the cause of reducing the standard of the engineer required, the Admiralty must take youths they can get. Fortunately, there is a bright side also: there are naval engineers officers, splendid engineers, some of the best, and they are also gentlemen. There is plenty of material amongst the ranks of the engine-room artificers for the making, by suitable training, into splendid engineer officer's mates. "E" should be given a fair chance. His promotion should not depend on the recommendations of his chief solely. The majority of engine-room artificer recruits have been obtained in the past through conscription, the conscription of starvation, when work has been slack. Some few have joined from a spirit of adventure, others have been lured by the lurid descriptions of naval life by sea-writers and artfully worded posters. Huge numbers have joined since the war from patriotic reasons. They are carrying out with them now a very bad impression of naval life. They are going to mix with their fellows; their ideas will spread.

I am, Sir, yours faithfully,

March 25, 1919. H. G.

POSITION OF THE OFFICIAL IN ENGINEERING WORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—In reference to the letter on the above subject by "Veritas," which appeared in a recent issue of your paper, may I say that a society is being built up exactly on the lines suggested by "Veritas," and with the objects he thinks it desirable such a society should have? If he and any other persons interested in this matter will communicate with me I shall be glad to give them further information.

Yours faithfully,

NORMAN WYLD.

25, Victoria-street, London, S.W.1,
March 26, 1919.

INDUSTRIAL UNREST; A PROPOSAL FOR ITS PACIFICATION.

To the Editor of Engineering.

Sir,—Apology is unnecessary for the introduction of a proposal to allay the industrial unrest now rife. The "Conlition of England question," as it was described in the 'thirties, is once more an alarming one. The elements of disturbance which five years ago were known to be stirring, but were little felt, have during the war developed in a way then undreamt of, and even now unappreciated.

Though a general survey of the position will take us over ground familiar to many, the gravity of the case must be my excuse for traversing it, on the way to the proposal of a possible remedy. It will also be, I believe, not without value to state the man's view in some detail, because the average employer and the man-in-the-street are strangely ignorant of it. The factors in the case are these: On the one hand a great body of the population of the kingdom, numerically a majority, is dependent upon its manual labours for the means of life. These labours are in most cases irksome and exhausting, and it is a curiously bitter phase of them that a certain amount of privilege is associated with the opportunity of undergoing them. There has never been any guarantee, short of ownership, that any man should continuously enjoy the opportunity of working at his industry. Many men have so worked, but they have not possessed any security of employment. It has always been open to their employer to close his shops or business and leave his men to find another employer.

In the engineering trade this would mean that the man must find some other person or association of persons possessing the costly tools of the trade and willing to employ him, still without guaranteed continuity of the opportunity to support himself and his family.

This element of uncertainty as to the future haunts even the best of workmen, and is, I fear, rarely considered by the employer, whose philosophy is that, if he is putting men off someone else is probably putting them on, and there are Labour Exchanges and unemployed pay.

Now, it will be freely granted that no stronger appeal than to his personal interest can be made to the normal man. What, then, results when the myriad socialist, syndicalist, anarchist and other speakers and writers address men situated as I describe ours to be? Consider the arguments showered upon them. The principal one is that the men are being robbed or "exploited" by the idle capitalist, whose dividends consist entirely of the sums he filches from the workman's earnings each week, or the difference, as they say, between what he earns and what necessity compels him to accept in lieu thereof. Money, the socialist now knows and preaches, is not a thing intrinsically valuable; it is in essence but a voucher commanding a certain amount of labour. Unless it command labour it ceases to have a value; the cost of the food and clothes we buy is due to the fact that someone laboured to produce them. The notorious experience of the gentleman who took out to Australia a great quantity of stores and luxuries, including carriages and some 50,000*l.* in cash, together with a large number of men to people his estate, never ceases to be quoted. It is hardly necessary to say that soon after arrival the gentleman—a noble Viscount—found himself deserted in his carriage with his gold and other baggage. With free land and the possibility of working for himself, no one cared to work for the Viscount, whose money at that stage of the community's existence was valueless.

Money, then, being a voucher representing so much labour, and the essence of fair dealing being value for value, the workman, it is said, is entitled to receive from his employer vouchers to the extent of his labour. In other words, for 50 hours of his work now he shall be able to claim 50 hours of some other's work. Does he receive this? asks the orator. Obviously not, or there would be no dividend to the idle capitalist, *whose money works for him*, who himself does nothing. This dividend is held by the studious working man to be simply the accumulation of amounts filched from him each week.

While this is a principal argument, it is not the only one. It is, however, the most plausible one now current, and the workman, holding it for gospel, does not fail to see that the campaign for ever-increasing wages will not finally improve his lot. He may by it reduce the proportion of his supposed due which the employer will retain, but he will not entirely prevent the retention of any part, nor will he ever in that way deprive the employer of the whip-hand which the possession of capital carries. At present the above doctrines, though they have produced not a little disturbance in the mind of the working man, have not been wholly accepted by the rank and file, who are more in accord with the less drastic policy, generally termed "the more equable division of the produce of labour." The socialist reformer's aim is to prove to him that this will not and cannot result in any lasting benefit to him. For, a rise in wages in one trade means an increased cost of the commodity produced by it, whence will come eventually a demand for increased wages in other trades and soon the first advance is swallowed or *nearly* swallowed by the increased cost of living. This economic fact is so well known that an apology is almost necessary for the introduction of it. Its value to the socialist is two-fold.

Firstly, it provides him with the strongest support for his proposal to abolish capital, and, secondly, it forms the basis of fresh demands for increased wages. The value to the socialist of the second clause is not at once obvious to the average man. It lies in the tendency these insistent, recurring demands have to destroy industry, a purpose dear to the socialist as the first step towards the inauguration of his own rule. If he can involve the industries of the country in disaster he can point to the result as the failure of the system of capitalism, the "immoral exploitation of the masses," and with more show of reason can demand the adoption of his scheme of things.

It is pointed out to the men, with adequate reason, too, that the old relation between men and masters are ended. For four years the men have been able to dictate their terms (we may, in passing, recognise to their credit the sense and patriotism of the leaders, who have done much to restrain their flocks), and the example of Russia is held up to them as an illustration of the ease with which he could emancipate himself were he but to take the trouble.

Remember, too, that he is now organised as never before—the non-society man is extinct—and he is told that in the last issue all he will have to do will be to stretch out his hand and take what he needs. "Here are he and his comrades anxious to work to produce the means of life, but the tools of their trade are the property of the idle few who may at any time, through caprice or incompetence, deny the workers access to or use of them. These are the days of democracy, and the few cannot be allowed to control the happiness, the very lives of the many. If they will not willingly surrender these so-called rights of theirs, the many must end the dispute by taking possession, and, when the time comes for that, there will be no resistance, because numbers are irresistible."

Now, all these things, and others, too, are dinned into the ears of the workman, and by many are accepted without consideration. They are to most tidings of the millennium. I have stated them at some length because I have discovered in many employers a complete ignorance of them, and, indeed, of the general trend of the men's opinions to-day. This is one of the most disquieting features of the case. The customary criticism an employer has to make of working-class propaganda is that the idea of all men being equal is too absurd to discuss and the men prove themselves to be fools when they put it forward. Rarely does an employer's knowledge take him beyond this imaginary tenet of socialism, a tenet embraced in no system I am acquainted with.

On the other side we have the employer and shareholder.

Their's are the views of most of your readers, and need occupy but a few lines.

The justification of the system of capital and profit is held by its advocates to be founded on an unassailable point of eternal law—the sacred right of property. (This law the socialist does most vehemently assail, recruiting to himself the while all those with little or none.) Grant him this, as most men unhesitatingly will, and it is an easy process to justify most of the facts of life to-day. The employer will further cite you, as a justification of his system, the notorious laxity and incapacity of State departments and undertakings; will point out, truly, that the ordinary man will not work except under the necessity of so doing for his family's support and his own; that the greatest stimulus to continued and valuable effort is the hope of monetary reward and increased comfort or prestige; that it is inherent in the nature of things that men should differ, that some should lead and others follow, some work with their brains and some with hands, that the latter are by temperament or endowment incapable of administering an undertaking; that it is open to any one to husband his earnings and become himself an employer (though at what age is not stated); that the country exists by trade and that an adverse trade balance must result in severe distress, if not national ruin, since by our exports we pay for the food our way of living compels us to import.

He will probably add that he himself believes in the betterment of the workman's lot, "consistently with the welfare of the industry."

Those are the most usual arguments on the employer's side, though there are, of course, others. I have not stated them, or the workman's, with the purpose of a critical examination of them, but merely to show the great and alarming difference which separates the two sides.

Failing any active measure of reconciliation, what are the prospects?

The employer, with few or no orders, finds himself in his search for them at some disadvantage because of the temper of labour, which may at any sign of reviving business impose some new demand on him; he finds himself confronted by a sterner American competition, not yet fully developed; and he finds international finance disorganised. The workman, on his side, after four years' of enormous demand for labour sees the commencement of unemployment, a circumstance usually preluding an attempt at a reduction in wages. He is determined to resist any move to depreciate his lot, to take from him any of his war gains; and he now, with deplorable lack of foresight insists on the restoration of the society rules and customs which have, in some places, been abrogated during the war. He lends, furthermore, a willing ear to the arguments we have summarised above, and he has been brought by the lavish expenditure of national funds to took upon the State purse as inexhaustible. Many of his leaders, it is true, are sagacious, moderate men, but their power in a crisis is small. It is in times of adversity that the wildest counsels prevail. Those times it must be the sole aim of the Government to avoid by some healthy means, and not by the method of State-doles or sops—a method akin, alike in theory and result, to the Danegeld.

There are abundant historical proofs of the fact that it is in time of adversity that socialism or communism gains popular favour, and a curious modern instance is seen in the custom prevalent in some factories, of a squad working individually when work is abundant and collectively when it is scarce. It is not, however, to be supposed that the whole result of a period of national distress would be a temporary measure of communism. Any such distress would find the Bolshevists amongst us with not a sprinkling of followers, but an army. The Government evinces its appreciation of this danger by its system of unemployed pay, but it somewhat fails in its duty when it omits to declare and emphasise its determination to limit the continuance of this pay. Many of the workers now enjoying it rely confidently on its renewal so long as they remain out of work—a frame of mind very favourable to the prolongation of the evil.

The situation of the engineering industry is stated, the writer believes, with impartiality and fair accuracy in the above remarks. If he has stated the case with any clarity one conclusion emerges—that, no matter what form the conduct of industry may finally take, the immediate need is a definite period of peace, long enough for the composure of the worst discords now rife and for the recommencement of useful work.

How may this be achieved?

The Industrial Councils, the closer unions between men and masters, &c., have been the basis of much hope and, I fear, little realisation. The frequent meetings of the parties have been usually for the purpose of arranging further increases of pay.

What I have to propose is to turn the machinery of negotiation to some more useful purpose, to establish some lasting terms of peace between the parties. I conceive that this can only be done by obtaining the assent of both sides to a definite partition of the cost of production.* The trouble may be regarded as a dispute concerning the relative reward due to each party—the manual worker, the owner of the plant, the brain-worker. Now, the present-day "labour-economist," if I may use that term to describe the reformers on the labour side, frankly admits the necessity to industry of the man of higher intellectual power, and admits his claim to remuneration greater than the manual worker's. In the ideal Republic, where State service shall be the motive of all work, equality of reward is conceived to be desirable and possible; in our society of to-day it is not regarded as feasible. Even the demand for the abolition of capital has been modified by the substitution of the "capitalist" for "capital," the chief social disadvantage being seen to be, not the existence of capital but its accumulation in private hands. To forbid and prevent that accumulation here and now would be well nigh impossible, but the modification of it is less difficult and would be salutary.

My proposal is a palliative, not a final remedy.

Let there be drawn up a scale of remuneration for the distribution of the cost of production of the commodity and of the proceeds from its sale, and let that scale be adhered to under guarantee for a definite period.

The obvious, instant comment on this suggestion will be that its execution would be impossibly complicated I am not of that opinion.

In the better-conducted works full analyses of the different elements of cost are now made, and the total cost is readily and simply reached. What my proposal amounts to is this: Let the master's representatives meet the men's to agree with them to a scale of standard basis-prices (feeds and speed, &c.) for the different operations involved, let them agree to a definite ratio of profit to be added to the final cost of the commodity, and let them agree to apply to themselves the premium bonus system now so popular; that is to say, to divide with the men who have served more than an agreed minimum time all profit over a certain percentage, say 3 or 4.

That is to say, the terms of the formulæ by which the various operation times are to be estimated shall be agreed upon by both the firm and the men's representatives, and all piece prices shall be fixed for a definite period by those agreed formulæ. It is unnecessary to state them in detail here; they are known or accessible to most of us.

The cost of material would be a factor outside the case, and could not be a cause of dispute. The clerical staff would have to be paid fixed salaries as at present, but should share in the excess profit distribution with all employees, with the possible exception of the highest-paid men. Directors' fees of any magnitude would be a stumbling-block unless really earned by actual work in the firm's interest. In any case they are hard to justify when they are the reward of nothing more than the occasional attendance at board meetings.

Let it be granted at once that the scheme proposed would involve an extension of piece work to almost every department in the works—a move likely to be viewed with distrust by many employers—but, as I shall show later, in modern shops rate-fixing is becoming an accurate science.

The case of a firm on repetition work presents far less difficulty or work than that of one on general and varied work. Even the latter class of work, however, can be run, by experienced people, entirely on piece work. At the same time be it remembered that every day sees the growth of specialised, repetition work and the elimination of the general shop.

The complexity of this scheme is more fancied than real. For, consider how few are the rate-fixers employed in a moderate-sized works, running on a fairly regular trade. All that my proposal involves is that the standard times they work on should be agreed to by the men's representatives, and the piece prices arrived at should be open to scrutiny by someone on the men's behalf; in a works employing 2,000 men this would need one man all his time; at the start, possibly two or three.

* Ordinary profit-sharing must be dismissed, for the cogent reason that under it profit is not likely to exist.

Were the scheme tried every price would no doubt be contested, but in time, when the method of rate-fixing came to be understood, probably most workmen would be able to check their own prices.

A more complex feature of the scheme is the fixing of the real cost and the addition of the profit. I conceive this proviso to be necessary to relieve the workman of the feeling of helplessness which is his when trade is bad, and to remove any suspicion of rapacity from the employer. The great obstacle would be the reluctance of the master to allow an examination of his costs, but it is not likely that any close examination would be demanded. If it were, it is true an impartial accountant could make it, but the publication of his certificate would involve an amount of publicity which most employers would dislike.

The uncertainty of profits, the workman's plea that he has but a share in creating them, and that perfect service on his part may be vitiated by incompetent management, is an admitted weakness of profit-sharing systems generally and is not peculiar to this scheme. Nor is it insuperable, or profit-sharing would not have existed.

Without wasting space in discussing the minutiæ of a proposal which I fear is doomed to as much ridicule as serious consideration, I propose to glance at the arguments for and against.

For it, I consider the following points to be of value :—

1. Its institution would for a definite period relieve the manufacturer of uncertainty as to his labour costs and would relieve his staff from much vexatious work.
2. It would end the awful waste of time arising now from disputes as to prices, malingering for the increase of them and "going slow" generally.
3. It would relieve the workman of the deadening knowledge or belief that his work is for others' benefit, and would give him an active interest in the success of the works.
4. It would remove the old bar to industrious work, the fear of a reduction in the piece price because, the basis price being fixed, the actual price would remain unchanged for the period of the agreement.
5. Its general adoption would compel all works to undertake proper rate fixing—a salutary process.
6. It would naturally and surely tend to the elimination of the slacker.
7. It would tend to induce a serener frame of mind in the men, productive of better and more work.
8. By giving them a real interest in the concern it would prove an antidote to Bolshevism.

Against it, I am prepared to hear that :—

1. It eliminates the dispute about individual piece prices by shifting the ground of argument to the basis price.
2. That, as already noticed, when men are granted a share of the profits they will soon come to demand an increased power of control and a larger insight into the conduct of the business.
3. Excessive complexity.
4. Shareholders will not agree to any such division of profits.
5. Periodical fluctuations in the basis price must cause the manufacturer immeasurable trouble in keeping his selling price up to date.
6. That not all of the operations in a works can be covered by basis prices.

I may be allowed a little space in which to glance at these objections.

1. I admit the possibility of this, but I suggest that definite standards of remuneration should be fixed, if necessary by the Ministry of Labour, for the different branches of industry. These standards would naturally be referred to the cost of living, which, in the times now imminent will, we may expect, be less variable than of late it has been. The adoption of these standards should in itself promote stability in the cost of production, i.e., living.

The certainty of dispute and propaganda at the times for reconsidering basis prices, even the certainty of political "lobbying," were the Ministry of Labour involved, I freely admit, but would they differ much from the dispute now rife? Would they at any rate, be so frequent?

2. This is inherent in any co-partnership scheme and does not entirely damn the present one.
3. I have already dealt with this.
4. Shareholders will probably agree to the division of profits rather than contemplate their disappearance, and the ruin of industry.
5. Fluctuations in cost would be less frequent than they have been during the last three years. Further, the machinery data for adjustment once in existence, the process would not be difficult or laborious.
6. Basis prices or rates are now used by rate-fixers, with remarkable certainty of result, to cover nearly all the operations in a works. A study of American literature on this subject will show that the process of accurate analysis of industrial operations has been carried in the United States of America far beyond anything usual in this country. The operations which could not be covered would be found to be insignificant.

Other aspects of industry which should be noticed in a letter of this nature are these: In justice to the workman and the nation we require better management and administration. Better relations between men and employers would give the staffs time to develop this and educate themselves in the scientific side of industry. The cry now common, that we are working American hours, paying American pay, we must have American output, is natural but, in fact, unreasonable. American output, if it be obtained in this country, will come through better management, achieved by better education in the subject and, probably, the application of better intelligence.

America, be it remembered, faced the high wage problem long ago, and it took her years to meet it. We should be greatly conceited to suppose that we can meet it in a few weeks, even knowing how she has met it.

And, finally, let us remember, in humility, that we are probably not by nature a manufacturing nation, that geological accident has made us so.

I am, yours truly,

CHARLES RUSSELL.

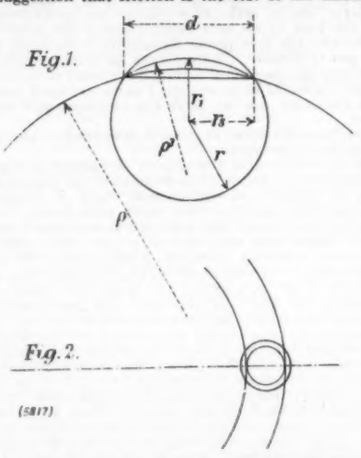
SLIDING FRICTION IN BALL BEARINGS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the valuable contribution appearing in your issue of February 28 by Mr. Arvid Palmgren, the author investigates and elucidates theoretically the magnitude of the losses of energy due to sliding between the balls and the races, and compares in this respect the single row groove bearing and the double row spherical bearing. His assumption is that "friction, more especially the sliding friction, must be the test of the efficiency of the bearing, particularly at high speeds." His conclusion is that the spherical bearing is the better of the two because the energy losses are less by computation.

The writer ventures to suggest that both assumption and conclusion ought to be qualified. Consider first the assumption. The term "efficiency" may mean so many things. To one it implies merely the ratio of power transmitted to power applied at any moment during the life of the bearing. Such an one would be quite alive to the fact that the time element was left out, and that in comparing the friction of two bearings of different design he was assessing their efficiency but not their durability.

To another efficiency is more or less synonymous with utility, and such an one is likely to be misled by the suggestion that friction is the test of the efficiency



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of a bearing. For to offer high power efficiency to one who wants high durability is like offering a stone to the hungry.

Bearings with flat ball races have less frictional losses than equally loaded bearings with grooved races, but their durability is not nearly so great owing to the far greater pressure per square inch between ball and race at the centre of their contacting surfaces when the area of contact is decreased.

In this case maximum pressure per square inch $= K/d^2$ approximately, where d is the width of the track or surfaces in contact and K is a constant.

If r = radius of ball unloaded,
ρ = radius of track unloaded in plane containing axis of bearing,
r' and ρ' = corresponding values for ball and track loaded.
d = width of contact,
and r_s = distance from edge of contact to axis of revolution of ball,

Then, by geometry,

$$r' = r_s + \rho' - \sqrt{(\rho'^2 - \tfrac{1}{4} d^2)}.$$

Now $2\pi(r' - r_s)$ is the distance that a ball revolving without slip on one of these circles will slip relatively to the other for one revolution of the ball about its axis.

$$\therefore \text{Slip} = S = 2\pi[\rho' - \sqrt{(\rho'^2 - \tfrac{1}{4} d^2)}],$$

from which it is clear that decrease of d, or increase of ρ' have the effect of reducing the slip. Increasing the radius ρ will have the effect of increasing ρ' and decreasing d and therefore of reducing friction. The condition for slip S to be zero is

$$\rho' = \sqrt{(\rho'^2 - \tfrac{1}{4} d^2)}.$$

This will be true if $d = 0$, and when d is not $= 0$ in the limit when ρ' is infinitely great. For d to be zero the load must be zero or the ball and ring be incompressible. When d is not zero for ρ' to be infinity, the track might be (1) convex and have a radius equal to that of the ball, or (2) cylindrical ($\rho = \infty$) and incompressible.

Since condition (1) is only realisable when the ball is running on a convex track having the same radius and elasticity as the balls, i.e., when the equilibrium is unstable, and condition (2) is unrealisable as incompressible materials are unobtainable, it will never do for the bearing manufacturer to act on the unqualified criterion that friction must be the test of efficiency of a bearing.

Next as to the author's conclusion. Even if it were conceded that friction is the measure of efficiency, is it altogether fair to leave out of the comparison the friction due to the cage? The forces developed here may be far greater than is commonly supposed. If one could assume, as is done by the author, in calculating the load on each ball that the balls are absolutely uniform in size, the omission would not be momentous; but since variation in size between one ball and another in the same bearing leads to different rates of revolution about the axis of the bearing, it follows that when a cage has been fitted in general one ball will tend to accelerate and another to retard it.

Consider two balls of slightly different size in a bearing. If r be the effective radius of the smaller ball and r' that of the larger, each of which is smaller than the radius of the corresponding ball unloaded, and R_o and R'_o be the effective radii of outer track, the former for the smaller, and the latter for the larger ball, and R_i and R'_i corresponding radii for the inner track; then for one revolution of the outer ring, the inner being stationary, the smaller ball will revolve $\dfrac{R_o}{R_o + R_i}$ and the larger $\dfrac{R'_o}{R'_o + R'_i}$ of one revolution about the axis of bearing.

Assuming area of contact between ball and inner ring to be the same as between ball and outer ring

Then

$$R_o + R_i = R'_o + R'_i$$

and angular velocity about axis of bearing is proportional to the effective radius of outer ring approximately and is therefore greater for the larger ball.

The pressure between the faster revolving balls and the cage will depend upon the load on the smaller ones and the co-efficient of friction between them and the ball races. When the pressure attained is sufficient to drag the smaller balls round they will slip at one or both of the races and wear smaller. When the bearing is of the spherical type with two rows of balls, the effect of end thrust is to increase the pressure on one and relieve that on the other row of balls. A result of this is that effective radius of the outer track for one row becomes different to that of the other, the balls on the smaller being dragged round by those on the larger through the intermediary of the cage. The fact that the small balls do wear more than the larger so that the difference between their sizes increases as the bearing is used, warrants the inference that the effect of the cage ought not to be left out of account in any comparison of the efficiency or durability of ball bearings.

The writer has no predilection in favour of either of the types compared by Mr. Palmgren, but realises that the efforts of British manufacturers to produce ball-bearings of better quality than those imported into the country before the war will be facilitated by a discussion of points like those raised by that author.

Yours faithfully,

HENRY L. HEATHCOTE.

Research Laboratory, Rudge-Whitworth, Limited, Bearing Works, Sparkhill, Birmingham, March, 25, 1919.

THE MICROGRAPHY OF ALUMINIUM AND ITS ALLOYS.*

By D. HANSON, M.Sc., Member, and S. L. ARCHBUTT F.I.C., Member (from the National Physical Laboratory).

THE micrography of aluminium and its alloys is a subject about which little has been written. During the past few years the use of aluminium alloys has greatly extended, and it is thought that an account of some of the different microstructural constituents which are met with in aluminium alloys, and the methods by which they may be etched for microscopic examination, will be of interest.

Preparation of Sections.—The preparation of sections of aluminium and its alloys for examination under the microscope demands an amount of care considerably greater than that required for steels and most of the commonly used non-ferrous alloys. In the first place, the sample should be removed from the mass of metal by sawing with a sharp hack-saw, and in the case of some aluminium alloys which are very soft, this operation must be carried out with the greatest care if good results are to be obtained, since distortion of the structure is very likely to take place, and such distortion may lead not only to an incorrect interpretation of the structure, but to considerable difficulty in etching. It has been found that deformed structures in aluminium alloys are very difficult to etch satisfactorily, since they tend to become covered with a layer of "tarnish" which is very difficult to remove except by repolishing, and which more or less effectively hides the underlying structure.

After removal of the specimen it should be carefully ground flat; for this operation it may be held lightly against a fast-running emery or carborundum wheel, or may be ground down with a file; in the latter case it is preferable to rub the specimen on the file rather than the file on the specimen, since flatter and less distorted surfaces are obtained by the former method. After this specimen is ground down in the usual manner on increasingly fine emery papers, finishing, as a rule, with that marked 000. Some workers prefer to stop grinding after using the 00 paper. For this operation the authors prefer hand-grinding, the papers being placed on a flat hard base. Success at this stage depends on the preparation of a surface which shall be as free as possible

* Paper read before the Institute of Metals, on Wednesday, March 26, 1919.

from included particles from the emery papers, which become detached and pressed into the surface of the specimen. Such a specimen can be polished in a very short time with excellent results; a surface in which much "dirt" is entangled can only be "cleaned" after being held for some time on the polishing pad, at the risk of relief polishing of the surface.

In soft alloys particles which become pressed into the surface of the specimen during grinding cannot be removed at all by polishing; the metal simply flows over them, giving a surface which appears satisfactory after polishing, but on etching the particles are again revealed and a dirty surface is obtained. Deep etching, followed by repolishing, is sometimes successful in removing this foreign matter, but deep etching leads to pitting of the surface, and the most satisfactory method is to re-grind the specimen with greater care. It cannot be too emphatically stated that time spent in careful grinding of aluminium alloys is amply repaid when the specimens are polished and etched. The need for care in grinding has been pointed out in connection with the metallography of alloys in general by a number of workers and, on account of this, hand-grinding of all metals and alloys has been adopted at the National Physical Laboratory in preference to mechanical grinding.

In order to prevent the entanglement of particles of emery from the grinding papers in the surface of the specimens, the device has been adopted of soaking the papers in paraffin oil before use. Some experimenters like to have the paper flooded with paraffin during the grinding, and practically to carry out the operation under paraffin. Occasional soakings, however, appear to be quite sufficient. This method has been used for some considerable time in the Metallurgy Department of the National Physical Laboratory, with satisfactory results. Other workers have prepared their papers by coating them with molten paraffin wax, and scraping off the excess. The authors have had no experience of this method, but understand that it gives successful results. In addition to these methods, the device suggested by Carpenter and Edwards of carrying out the final stages by rubbing the specimen on blotting paper has been tried, but without much success.

Fig. 1.

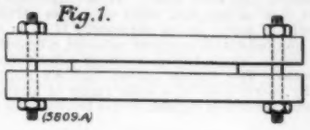

FIG. 2.—Aluminium containing 1% iron and 1% silicon; unetched. Shewing $FeAl_3$ (white) and silicon (grey) in aluminium. Magnified 1000 diameters.

FIG. 3.—Same as in fig. 2; etched in 4% HF for 45 seconds. $FeAl_3$ (large dark needle) and silicon in aluminium. Magnified 1000 diameters.

FIG. 4.—Aluminium sheet—as rolled, etched with 4% hydrofluoric acid. Magnified 150 diameters.

FIG. 5.—Aluminium sheet—annealed, etched with 4% hydrofluoric acid. Magnified 150 diameters.

In the case of thin strip or rolled sheet, this may be prepared for examination in the plane of rolling by attaching it to another piece of metal or other substance, as, for example, a piece of wood, by means of sealing-wax, bitumen, or similar substance. The preparation of cross-sections of thin sheet is a more difficult matter. It may, however, be done by means of a simple device, which has been used with considerable success. Two plates of a suitable metal about ¼ in. thick are bolted together by means of two small bolts, with the sample of sheet to be examined between them. The small sample and the two plates of the "clamp" are then ground down together until a flat surface is obtained, when the composite surface is polished in the usual manner. It is advisable to remove the thin sample of sheet before etching, as the etching liquid tends to collect in the space between the sample and the supporting plates, and is difficult to remove satisfactorily. Levelling of the specimen then becomes a matter of increased difficulty, but this may be overcome in some cases by returning the sample to the clamp for examination. A sketch of the apparatus is shown in Fig. 1.

For the polishing operation, as distinguished from the grinding operation, the normal method adopted at the National Physical Laboratory is to use a rotating metal disc covered with good quality smooth-surfaced woollen cloth, and driven by an electric motor, the speed of which can be varied at will by means of a regulating resistance. The pad is moistened with distilled water, and a little magnesia powder is placed on it and rubbed over the surface with the finger. The pad is then made to rotate while the specimen is held against it in such a manner that it is rubbed in a direction at right angles to the scratches, the pad being moistened occasionally by means of a jet of distilled water from a wash bottle. When the scratches produced during grinding have been removed, and this should not take more than 4 minutes or 5 minutes, the specimen, except in the case of some of the harder alloys of aluminium, will be found to be covered with a series of very fine scratches in the direction in which the pad has passed over the specimen. The pad may be rotated during this part of the operation at a speed of about 500 r.p.m. In order to remove these fine scratches the pad should be washed nearly free from the polishing powder with distilled water and again rotated, generally at a slower speed than before, which speed will depend largely on the hardness of the alloy. The specimen is now again held against the polishing pad, but is rotated slowly in the opposite direction to that in which the pad is moving, so that it is rubbed equally in all directions. A copious supply of water should be used, in order to keep the pad quite wet throughout the operation, and by this method the fine scratches produced on soft metals by the polishing powder can be removed.

Too much importance cannot be attached to the nature and condition of the cloth surface when aluminium alloys are being polished, since they demand the maximum possible softness of surface. A woollen material free from cotton is to be recommended, and it will usually be found that it requires to be used for some time before it becomes properly "broken in," and acquires the beautifully soft surface which is necessary to give the best results. During the last year or two the quality of the cloth which it has been possible to obtain has been rather inferior, and especially has this been the case during the year 1918, and in a number of cases special methods have had to be adopted. One of the most successful substitutes for the cloth polishing pad is one made of chamois leather, but here again it is a matter of some difficulty to obtain satisfactory samples, and the leathers must be carefully selected, only the softest being suitable for aluminium alloys. Chamois leather pads need not be rotated so quickly as cloth pads; indeed, the leather "grips" the specimen to such an extent that it is practically impossible to hold it against a pad which is rotating at a high speed. In the case of the softer alloys of aluminium, all that is necessary is to rub the specimen lightly on a piece of wet chamois leather fastened to a piece of plate glass, magnesia being used as the polishing powder. This method of finishing by hand is particularly useful for obtaining a good finish on a specimen which has been prepared by polishing on a cloth pad. Selvyt cloth and a number of cotton fabrics of various descriptions have been used from time to time, but the methods described above have been found the most successful.

Magnesia powder is extremely suitable for polishing aluminium and its alloys. It can be bought ready for use, and does not as a rule require any troublesome preparation. It is sold by a number of manufacturers of pure chemicals under the name of "heavy magnesia powder"; if, as occasionally happens, it should be found to contain some hard particles, it should be heated to about 900 deg. C. for an hour in a porcelain dish, and re-ground in small quantities in a porcelain mortar. It has one serious objection, that it forms a carbonate when exposed to moist air, and it is therefore necessary to be extremely careful to wash the polishing pad quite free from powder immediately after use, since otherwise the carbonate forms a hard incrustation in the pores of the cloth, and scratches the specimen. As an additional precaution it is also desirable to use only distilled water in contact with the magnesia, since dissolved CO_2 and soluble carbonates also lead to the precipitation of carbonate in the cloth. A cloth that has become accidentally contaminated with magnesium carbonate need not, however, be rejected, but the carbonate may be dissolved out with dilute hydrochloric acid, without injury to the fabric. The cloth must, however, be well washed with water after this treatment, to remove the acid.

Hand-polishing with metal polish on chamois leather may also be used, but it offers no advantages over the methods described, and is open to the objection that the polish enters holes in the surface, such as frequently occur in sand castings, and is difficult to wash out. This method of polishing is not so satisfactory with aluminium alloys as it is with copper alloys, where it gives excellent results.

The Micrographic Constituents of Aluminium Alloys.—Aluminium alloys are among the most difficult alloys which the metallographer has to etch. They exhibit a great readiness to become "tarnished," especially by aqueous solutions, probably by the formation of an adherent coating of hydrated oxide of aluminium, which it is extremely difficult to remove, either chemically or mechanically, without destroying the etched surface of the specimen. This applies especially to metal which has been cold worked, and the preparation of perfectly etched specimens of such material is a matter of great difficulty.

Pure Aluminium.—Aluminium is a metal which it is very difficult to obtain in a chemically pure condition.

Certain impurities, of which the most noteworthy are iron and silicon, are always present in greater or less amount.

Iron occurs in aluminium as the compound $FeAl_3$,* which is practically insoluble in solid aluminium. The solubility is so small that no sample which the authors have yet examined is quite free from $FeAl_3$; in a sample containing only 0·1 per cent. of iron an appreciable quantity of this compound is present in a free state, even after prolonged annealing. It should be realised, however, that the amount of impurity is in reality greater than 0·1 per cent. in such a case, since every atom of iron combines with three atoms of aluminium to form the compound $FeAl_3$, which is, strictly speaking, the impurity. $FeAl_3$ is visible in polished aluminium specimens without etching. It is a hard compound, whiter in colour than aluminium itself, and readily takes a high polish.

Silicon is also an impurity which is always present in aluminium, to a varying extent, less than 0·1 per cent. being seldom found, while it may sometimes reach 1·0 per cent. Silicon forms a simple eutectiferous series of alloys with aluminium,† having a eutectic at 10·5 per cent. of silicon, the melting-point of the eutectic being 570 deg. C.

$FeAl_3$ and silicon are not easy to distinguish from one another under the microscope, unless they are seen together, though with experience this difficulty becomes considerably diminished. Silicon appears as the darker of the two constituents; Fig. 2, page 451, under a magnification of 1,000 diameters, shows both constituents in the same field of the microscope; the one large piece of light-coloured constituent represents the iron compound, and the smaller dark pieces are silicon, both being embedded in a matrix of aluminium. The alloy from which this section was taken contains 1 per cent. of iron, and 1 per cent. of silicon, and was photographed in the unetched condition. These constituents may be distinguished from one another somewhat more readily by etching. Silicon itself appears to be attacked with great difficulty by any etching reagent. $FeAl_3$, on the other hand, is somewhat readily attacked. The most suitable reagents are caustic soda (20 per cent.) and dilute hydrofluoric acid. Twenty per cent. caustic soda attacks $FeAl_3$ somewhat slowly, and if the attack is not continued for too long it is a useful reagent. It emphasises the difference between the $FeAl_3$ and the aluminium, the contrast between which is not very great in unetched specimens. A light etch of about 30 seconds causes the iron compound to become distinguished from the aluminium by the appearance of a dark boundary line between the two. Deep etching causes the compound to be dissolved out, leaving small cavities in the specimen.

Hydrofluoric acid, of a strength not greater than 5 per cent., colours the iron compound to an extent which depends on the length of the attack; when suitably etched the iron compound is stained a light brown colour, which is sufficient readily to distinguish it from silicon, and from most of the other constituents found in aluminium alloys. Fig. 3, page 451, represents the same alloy as that shown in Fig. 2, after etching in 4 per cent. hydrofluoric acid for 45 seconds. The central needle-shaped piece of iron compound here appears darker than the silicon which surrounds it.

Hot 5 per cent. nitric acid also colours $FeAl_3$ a light brown, but the attack is not very regular, and the strength of the acid must be carefully regulated; if the strength is much greater than that indicated no colour is produced.

In addition to the recognition of the various constituents in aluminium it is very frequently required to develop the crystalline structure of the aluminium itself, and for this different methods are more suitable. For this purpose two reagents most frequently used are aqueous caustic soda (about 20 per cent.) and aqueous hydrofluoric acid. The latter, the use of which was first suggested by Brislee, may vary in strength between wide limits, but for sections which have to be examined under the microscope a 10 per cent. solution has been found very successful. For revealing coarsely crystalline structures such as are sometimes found, which do not require detailed microscopic examination, a stronger solution is more suitable. A little nitric acid is sometimes added to the solution of hydrofluoric acid. Fig. 4, page 451, represents the structure of a piece of aluminium sheet, etched with this reagent, under a magnification of 150 diameters, and Fig. 5, on the same page, the same metal after annealing.

These two reagents give fairly satisfactory results, but they sometimes produce badly tarnished surfaces, from which the surface deposit is difficult to remove. This may sometimes be effected by immersing the specimen in chromic acid solution or in 50 per cent. nitric acid solution, but this is by no means always successful. Metal which has been cold worked is much more liable to tarnish during etching than metal which has not. Of the two methods, the use of hydrofluoric acid is probably more successful with pure aluminium, but caustic soda is probably more useful for alloys.

Copper Aluminium Alloys.—In all commercial light alloys copper, when present, exists as the compound $CuAl_2$, which forms with aluminium a eutectic containing 34 per cent. of copper, and having a melting-point of 535 deg. C. The alloys of these metals have been studied by Carpenter and Edwards.‡

$CuAl_2$ is generally visible as a white bright constituent in the unetched sample. In this condition, however, it can only be distinguished with great difficulty from $FeAl_3$ and a number of other constituents sometimes found in aluminium alloys, and some method of etching is necessary to identify it with certainty. By far the most distinctive etch for this compound is obtained by the use of a 20 per cent. solution of nitric acid in water, at a temperature of 70 deg. C., the specimen being immersed for a few seconds only, two or three being as a rule sufficient, after which it is immediately removed and plunged into cold water. It is important to carry out this etch as directed, since otherwise variability in the result is likely to be obtained. If it is carefully carried out the $CuAl_2$ becomes coloured a beautiful dark brown colour, $FeAl_3$ and most other constituents being unattacked. The brown colour can be imparted to $CuAl_2$ by nitric acid of a wide range of strength, but the results are not so regular, nor is the contrast between the $CuAl_2$ and the iron compound so clearly brought out. A sample of a copper-aluminium alloy containing 12 per cent. copper, etched by the above method, is shown in Fig. 6, above, under a magnification of 150 diameters. Fig. 7, also above, is an alloy containing 2 per cent. of copper, 3 per cent. of silicon, and about 0·3 per cent. of iron, etched in the same manner with hot nitric acid. The $CuAl_2$ appears black in the photograph, $FeAl_3$ is seen in the form of long white needles, while the bluish-grey silicon is of an intermediate tone.

Zinc-Aluminium Alloys.—Zinc can enter into solid solution with aluminium at atmospheric temperatures up to a concentration of 40 per cent. of zinc. Commercial alloys seldom contain more than 20 per cent. of zinc, and these all fall well within the range of the solid solution alloys. The alloy system has been examined by Rosenhain and Archbutt,* who have also described methods of etching these alloys. Some additional information can now be given. The methods used for pure aluminium are also applicable to alloys containing zinc, but the caustic soda reagent is perhaps better in this case than hydrofluoric acid. Twenty per cent. aqueous caustic soda develops the crystal structure of aluminium-zinc alloys after an immersion of about 1 minute. At the end of this time the alloy is usually covered with a thin black deposit, which more or less completely hides the true structure. This deposit can be removed by immersing the specimen in a solution of chromic acid in water for a few moments, when the structure is more clearly revealed. Fifty per cent. nitric acid in water may also be used for removing this deposit, but chromic acid is on the whole more satisfactory. This is not the only surface deposit which is produced on etching zinc-aluminium alloys. In some cases it is found that after the removal of the black deposit the surface is still covered with a light-coloured tarnish, which is extremely adherent, and cannot be removed either mechanically or chemically without destroying the etched surface. The best method of avoiding this tarnish effect is to use great care during the grinding and polishing operations, and to avoid all unnecessary distortion or dragging of the surface at any stage during the preparatory operations. It is sometimes useful to preserve the black deposit on the surface of a specimen; for example, if it is desired to reveal the cored structure of a casting, a light etch in caustic soda, without treatment in chromic or nitric acid, is satisfactory. The zinc-rich portions of the crystals are the first to become covered with this deposit. Fig. 8, above, is a photomicrograph of a zinc-aluminium alloy containing 25 per cent. of zinc, in a hot-rolled condition, etched in the manner indicated. Fig. 9, above, is a photomicrograph of an alloy containing 17 per cent. of zinc, after cold drawing. In this latter case, although the black deposit has been removed by the immersion in chromic acid, a certain amount of "tarnish" has been left on the surface of the alloy.

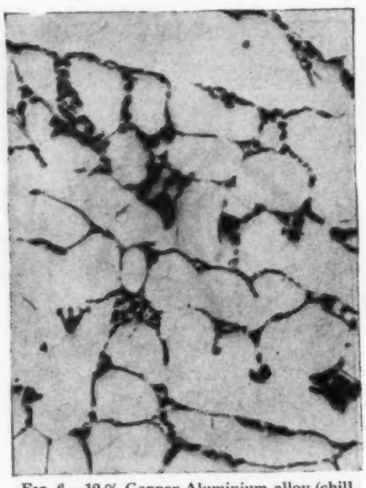

FIG. 6.—12 % Copper Aluminium alloy (chill cast), etched with 20 % HNO_3 at 70° C. for 2-3 seconds. $CuAl_2$ shown black in photograph. Magnified 150 diameters.

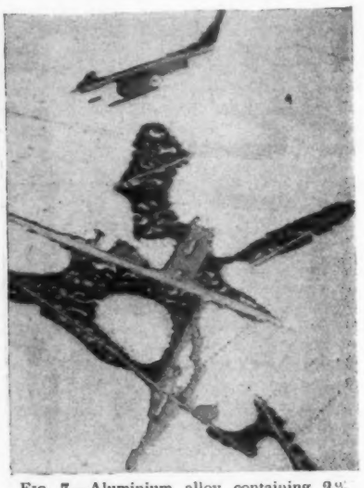

FIG. 7.—Aluminium alloy containing 2 % copper, 3 % silicon, and 0·3 % iron (sand cast), etched as fig. 6. $CuAl_2$ is shown black, $FeAl_3$ as white needles, silicon as half tone. Background is aluminium. Magnified 500 diameters.

FIG. 8.—25 % Zinc Aluminium alloy, as rolled (hot), etched with 20 % aqueous caustic soda. Magnified 150 diameters.

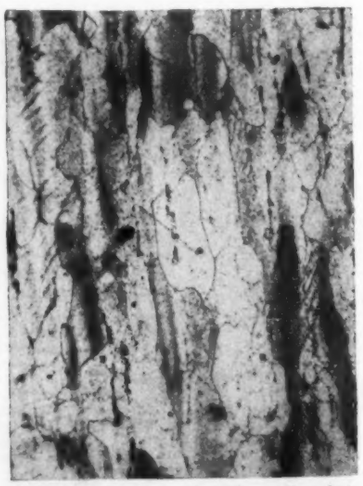

FIG. 9.—17 % Zinc Aluminium alloy—hot rolled, annealed and cold-drawn, etched as fig. 8. Magnified 150 diameters.

* Gwyer, *Zeitschrift für anorganische Chemie*, 57, 113 (1908).

† Fraenkel, *Zeitschrift für anorganische Chemie*, 58, 154 (1908).

‡ Carpenter and Edwards, Proceedings of the Institution of Mechanical Engineers, 1907, page 57.

* Rosenhain and Archbutt, Philosophical Transactions, 1911, 211A, 315.

This is possibly due to the fact that the alloy is in a cold-worked condition, but there is also evidence that the grinding operation has not been very well carried out. In a number of places in the section dark parallel markings can be seen, which have the appearance of wide scratches. These were not visible on the polished specimen, and their appearance on etching indicates that some local distortion of the surface, produced during the grinding operation, remained in the specimen, and this distortion is probably partly to blame for the tarnishing of the surface.

A modification of this method is to use an alcoholic solution of caustic soda instead of an aqueous solution. A saturated solution is generally used, but a few drops of water should be added or etching will not take place to any appreciable extent. In any case, the reaction is very slow, about half an hour being required as a rule. The black deposit referred to above is also formed during this etch, and may be removed by chromic acid. The method has some advantages over the aqueous soda etch, as the $FeAl_3$, $CuAl_2$, and other constituents which are sometimes found in aluminium alloys appear to be rather less readily attacked by the alcoholic than by the aqueous reagent, and the specimen is therefore less liable to become pitted. The advantages of the reagent are not, however, very considerable, much the most important factor in the successful treatment of these alloys being the careful preparation of the specimen during the grinding and polishing operations. Fig. 10, above, is a photomicrograph of an alloy containing 3 per cent. of copper and 20 per cent. of zinc, in a hot-rolled and annealed condition, after etching with this reagent and cleaning with chromic acid.

Nickel-Aluminium Alloys.—Nickel forms a compound $NiAl_3$ with aluminium,* which is in many ways similar to $FeAl_3$. It forms, with aluminium, a eutectic containing 6 per cent. of nickel, and having a freezing point of 630 deg. C. It has a very limited solubility in solid aluminium, and occurs in the alloys as a hard white constituent, similar in appearance to $FeAl_3$ and $CuAl_2$.

$NiAl_3$ may be identified by etching with 10 per cent. caustic soda, which stains it a brown colour. Fig. 11, below, shows an alloy containing 2 per cent. of nickel, etched in this reagent for 30 seconds. Dilute hydrofluoric acid may also be used for these alloys, a strength of 5 per cent. or less being suitable. This reagent also stains the nickel compound brown, and gives an etching effect practically identical with that obtained with caustic soda. Both these reagents may be used to distinguish $NiAl_3$ from $CuAl_2$, which remains unattacked by them. Fig. 12, above, under a magnification of 150 diameters, shows an alloy of aluminium containing 2 per cent. of nickel and 4 per cent. of copper, etched with 20 per cent. caustic soda. The $NiAl_3$ is stained brown, and appears dark in the photograph, while the $CuAl_2$ is unattacked and appears white. The hot 20 per cent. nitric acid reagent may also be used for distinguishing these two constituents, the $CuAl_2$ in this case being coloured brown, and the $NiAl_3$ remaining unattacked.

$FeAl_3$ is very difficult to distinguish from $NiAl_3$ when the two metals occur together in the same aluminium alloy, and the equilibrium conditions of iron-nickel-aluminium alloys are not known. $FeAl_3$ when it occurs alone in an aluminium-iron alloy, is unattacked by short exposures to caustic soda, but in the presence of nickel $FeAl_3$ either ceases to exist as such in the alloy, or assumes etching properties very similar to those of $NiAl_3$. The authors do not know of any reagent which will reveal the presence of $FeAl_3$ and $NiAl_3$ as different constituents in the same aluminium alloy.

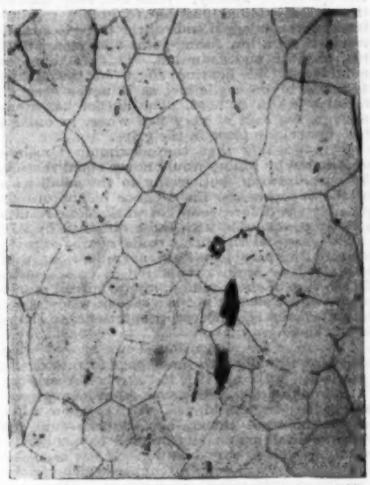

FIG. 10.—Aluminium alloy containing 3% copper and 20% zinc—hot rolled and annealed at 450° C. Etched with alcoholic NaOH. hon ogenous solid solution. Magnified 150 diameters.

FIG. 11.—Nickel Aluminium alloy containing 2% nickel (as cast), etched with aqueous 10% NaOH for 30 seconds. $NiAl_3$ appears dark in photograph. Magnified 150 diameters.

FIG. 12.—Aluminium alloy containing 4% copper and 2% nickel (as cast), etched with aqueous 10% NaOH at 30°C. for 30 seconds. $NiAl_3$ coloured dark, $CuAl_2$ light. Magnified 150 diameters.

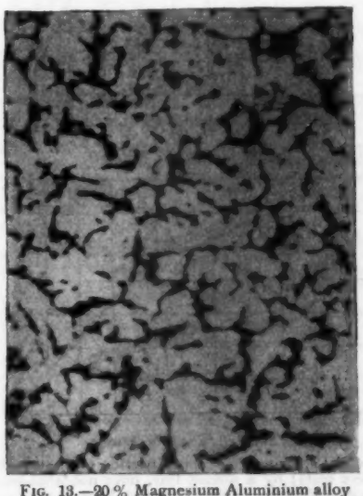

FIG. 13.—20% Magnesium Aluminium alloy (as cast), etched with 1% alcoholic nitric acid for 15 minutes. Aluminium-magnesium compound shown black. Magnified 150 diameters.

Magnesium-Aluminium Alloys.—The alloys of aluminium with magnesium have been investigated by Grube,* whose diagram is at present the only one available. The results of investigations carried out at the National Physical Laboratory indicate that this diagram can only be regarded as tentative. The addition of more than about 6 per cent. of magnesium leads to the formation of a second constituent in magnesium-aluminium alloys.

Grube used a solution of ammonium chloride as an etching reagent, but an alcoholic solution of nitric acid containing 1 per cent. to 10 per cent. of nitric acid has been found more suitable. This colours the magnesium constituent brown, the length of immersion which is necessary depending on the strength of the solution. With the 1 per cent. solution about 15 minutes are required. This reagent leaves the usual impurities in aluminium unattacked. Fig. 13, on this page, shows an alloy containing 20 per cent. of magnesium etched with this reagent.

Manganese-Aluminium Alloys.—The authors have no knowledge of any reagent which will colour the manganese-aluminium compound $MnAl_3$. They have had no experience of this constituent, except in alloys containing a certain amount of copper, in which the manganese compound can be distinguished from the copper compound by means of the hot nitric acid reagent. In some of these alloys the $MnAl_3$ can be distinguished by its form, since it crystallises out in the form of well-defined cubes. It is visible in the specimens before etching.

The above summary describes the metallographic characteristics of most of the constituents met with in binary alloys of aluminium, and in some ternary and still more complex alloys, and it is hoped that the etching methods outlined in this paper will be of assistance to metallographers who have to deal with "light alloys" containing high percentages of aluminium. The development of new etching reagents is a long and tedious process, and this is especially so when it is required to find methods of distinguishing between a large number of different constituents of similar properties, such as the different compounds met with in the usual aluminium alloys. The results described in this paper have been collected gradually during the past five or six years, in the course of researches into the constitution and properties of a large number of aluminium alloys carried out by the Department of Metallurgy in the National Physical Laboratory.

The authors desire to acknowledge the assistance they have received in this connection from a number of their colleagues collaborating in these researches, notably Miss C. F. Elam; Miss P. Routh, B.Sc.; Miss K. Bingham, B.Sc.; Miss M. L. V. Gayler, B.Sc.; Mr. F. S. Tritton; and Mr. S. A. E. Wells. In particular, they would like to express their appreciation of the stimulating encouragement and guidance which they have always received from Dr. W. Rosenhain, F.R.S., under whose direction all these investigations have been carried out.

Finally, they wish to express their indebtedness to Sir Richard Glazebrook, C.B., F.R.S., Director of the National Physical Laboratory, for permission to publish the results.

TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.—A very important agreement has been come to between the Institution of Automobile Engineers, the Society of Motor Manufacturers and Traders and the Association of British Motor and Allied Manufacturers, in regard to the future handling of all technical matters connected with the automobile industry and the relations between the industry and the British Engineering Standards Association. It will be remembered that in 1917 the Technical Committee of the Motor Industries was founded by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders, as an administrative body to consider matters in connection with standardisation, research, &c., and to co-ordinate investigation in connection therewith. By the arrangement just come to this committee will be disbanded, and the functions exercised by it will in future be carried out by a Technical Committee appointed by the Association of British Motor and Allied Manufacturers. The latter body was, of course, formed to look after the commercial interests of the British automobile building firms, and it has therefore agreed to conditions which will ensure that the technical qualifications of that committee shall be properly safeguarded. One of these conditions is that not only shall a preponderance of the members of the Technical Committee be full members of the Institution of Automobile Engineers, but the Association of British Motor and Allied Manufacturers will also appoint to that committee a certain number of members actually nominated by the Institution; further, the Institution will, subject to the approval of the British Engineering Standards Association, have independent representation on the Automobile Sub-Committees of that Association. In future, therefore, all technical matters relating to the industry should be referred to the Technical Committee of the Association of British Motor and Allied Manufacturers, 39, St. James'-street, London, S.W. 1, which will form the only means of communication between the industry and the British Engineering Standards Association, the latter body being, as before, solely responsible for the issue of all standards and for seeing that all other industries interested in any standardisation put forward shall be consulted.

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* Gwyer, *Zeitschrift für anorganische Chemie*, 57, 113 (1908).

* Grube, *Zeitschrift für anorganische Chemie*, 45, 225 (1905).

THE INFLUENCE OF COLD-ROLLING UPON THE MECHANICAL PROPERTIES OF OXYGEN-FREE COPPER.*

By F. JOHNSON, M.Sc., Member, Birmingham.

AT the September, 1918, meeting of the Institute a paper was read by W. E. Alkins,† in which it was shown that, by progressively cold-drawing copper wire of any diameter, "a stage is always reached when the area of the wire has undergone a reduction of about 50 per cent. where, over a limited range, further drawing causes no corresponding alteration in properties. Moreover, the physical properties corresponding to this constant range are always the same; thus, the density is 8·889, the specific volume is 0·11251, the tensile strength is just over 23 tons per square inch, and so on."

Two points were raised in the discussion by Dr. Rosenhain and the author, which it appeared desirable to clear-up, viz.:—

1. Whether the presence of cuprous oxide was in any way responsible for the abrupt change of state, and

2. Whether the same kind of change would occur if the metal were cold-rolled from the annealed state instead of being cold-drawn.

The author had reason to believe that the cuprous oxide in Alkins' specimens could have little or no influence on the change of state, owing partly to the smallness of the amount and partly to the coalesced condition in which it probably existed. It was unfortunate that the amount of oxygen was not quantitatively determined, but Alkins pointed out in the discussion that electrolytic determinations showed that the copper content exceeded 99·9 per cent., thus leaving somewhere about the normal amount of cuprous oxide usually found in tough-pitch copper.

It seemed probable, too, that the same change should occur with rolled copper as with drawn copper.

The only way in which it appeared possible to obtain a sound piece of pure copper, free from oxide and from possible contamination by any element derived from the use of a deoxidiser, was to melt a sufficient quantity of electro-deposited copper under a suitable "cover," which would exclude oxygen. "Boronising" suggested itself, but the author has had insufficient experience with this method to justify an attempt being made.

The method he adopted was to melt the copper in a graphite crucible under a very generous layer of fine charcoal‡ and add further portions, step by step, until the crucible was full of molten copper. The metal was allowed to solidify and cool in the crucible under its layer of charcoal, and was taken out when cold. The "button" thus obtained was well piped, but otherwise very sound and extremely tough. The top third, containing the "pipe," was cut off, and the remaining portion, weighing 3¾ lb., was heated to 900 deg. C. and forged on the anvil.

The forging reduced the thickness from 3 in. to ½ in., it being necessary to re-heat twice for forging and once more in order to remove scale by quenching in pickle (dilute sulphuric acid). The disc was then passed through the rolls to obtain uniformity of thickness, annealed and quenched. It was then passed cold through rolls in successive stages, without annealing, as shown in Table I.

TABLE I.—*Tests on Cold-Rolled Copper (Assaying 99·99 per Cent. Copper).*

No.	Thickness.	Percentage Reduction in Rolling.	Condition.	Maximum Load. Tons per Sq. In.	Elongation per Cent. Length = 4 √ area.
	in.				
1	3·0	—	Slowly cooled from fusion	8·88	45·0
2	0·453	—	Forged hot and annealed	13·72	57·8
3	0·309	31·8	1st pass ..	20·77	21·1
4	0·244	46·13	2nd pass ..	22·65	18·05
5	0·168	62·9	3rd pass ..	23·53	17·7
6	0·103	77·2	4th pass ..	25·48	12·8
7	0·088	80·57	5th pass ..	26·82	11·9
8	0·075	83·44	6th pass ..	26·90	12·5
9	0·057	87·4	7th pass ..	27·54	10·0
10	0·050	88·96	8th pass ..	27·90	7·8
11	0·044	90·28	9th pass ..	28·25	—*
12	0·034	92·5	10th pass ..	28·65	—
13	0·024	94·7	11th pass ..	29·50	—
14	0·015	96·67	12th pass ..	—	—
15	0·010	97·79	13th pass ..	30·00	—
16	0·0075	98·35	14th pass ..	30·85	—
17	0·0050	98·9	15th pass ..	—	—
18	0·0035	99·22	16th pass ..	—	—

* There was no further lowering of elongation, but the gauge-lengths at this stage became too small for the measurements to be considered sufficiently accurate for placing on record.

A piece was cut off at each pass, and from each piece tensile test-pieces were prepared. The results of the tensile tests are tabulated (Table I), and the figures for maximum breaking load are plotted as ordinates against percentage reductions of thickness as abscissæ in Fig. 1.

* Note read before the Institute of Metals on Wednesday, March 26, 1919.

† "The Effect of Progressive Cold Work upon the Tensile Properties of Pure Copper," See ENGINEERING, vol. CVI, page 283.

‡ Borax glass suggested itself, but it was thought not to offer such completeness of deoxidising action as charcoal, although by continuously feeding the copper into a bath of molten borax, oxidation may possibly have been prevented entirely.

The elongation figures are also plotted.

The tensile strength curve is seen to consist of two rectilinear portions joined by a curved portion, as Alkins showed for drawn "tough-pitch" copper. The change which takes place, denoted by the curved portion (or intermediate range) is at about the same value, viz., 23 tons per square inch.

There is, however, no horizontal portion, but a marked check in the rate at which the tensile strength increases, there being a small increase of strength for each successive pass over the intermediate range.

At 80 per cent. reduction there is another step in the curve, the tenacity rate of increase showing an abrupt check at this stage. In a subsequent set of tests on freshly-rolled metal (utilising portion of strip No. 5 for the purpose) the occurrence of this step was not confirmed.

These tests (7a to 9a) are shown as stars on the curve (Fig. 1), and fall approximately on a straight line. The

Fig. 1. TENSILE TESTS OF STRIPS AS ROLLED.

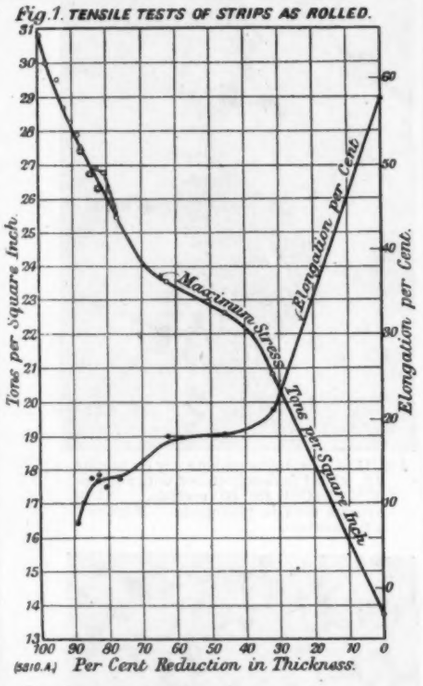
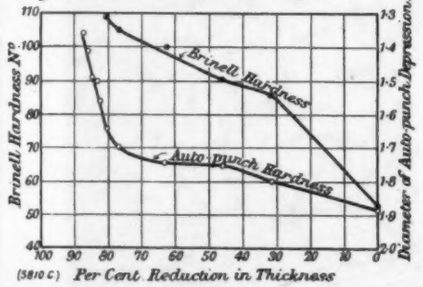


Fig. 2. HARDNESS OF STRIPS AS ROLLED.



author, whilst showing the stepped portion (as indicated in the first tests) by a dotted line, does not abandon belief in its existence. It is confirmed by a change of direction in the hardness curves, as well as by a change in the rate of decrease of elongation. The position of the tensile stress value for No. 7 (80·5 per cent. reduction) admits of no dispute, the figures given representing the average of three closely concordant tests, viz.:—

1. 26·82 tons per square inch.
2. 26·83 tons per square inch.
3. 26·86 tons per square inch.

It is possible that the influence of time ought not to be ignored. In the first set of tests there was a lapse of two weeks between rolling and testing, but only an interval of two days in the case of the check tests.

The results of the three check tests are as follows:—

No.	Maximum Stress. Tons per Sq. In.	Elongation per Cent. $l = 4\sqrt{\text{area}}$.
7a	26·33	13·0
8a	26·77	12·7
9a	27·43	10·0

The author intends to make a more exhaustive examination of this phenomenon, and therefore reserves such confirmatory evidence as he possesses for publication in a later paper. There is, for instance, an indication of an arrest at 80 per cent. reduction in the rate of decrease of specific gravity, which had reached a maximum in the neighbourhood of 46 per cent. reduction.

With the thinner gauges a number of possible errors may creep in. The slightest divergence from correct alignment of the rolls might leave the sheet thicker and of different mechanical properties on one side than on the other. If the test-piece were taken from the thinner side and in the succeeding pass from the thicker side, assuming the same error in alignment of rolls to have been made, the increase in tensile strength, &c., might not be commensurate with the supposed percentage reduction. Correct gauging should, of course, reveal any error of this kind. Another source of error lies in non-axial loading of the specimens. This is difficult to secure with small flat strips. Every care was taken to fix the specimens axially. With the very thin specimens it was only found possible to obtain results by perforating the enlarged ends of the test-pieces and pouring round them a low fusing-point alloy consisting of lead, tin, bismuth and cadmium. This was done in a sand mould and the heating effect on the specimen was assumed to be negligible, as it never became uncomfortably warm to hold. The author has adopted this plan in the case of very fine wires, in order to avoid fracture taking place in the grips.

It is possible that the maximum tensile strength obtainable by rolling would never equal that obtainable by wire drawing, but, owing to the small-scale nature of the experiments, the absence of cuprous oxide and possibly the difference in hot work, these results are not strictly comparable with those obtained by Alkins.

The shape of the curve could not be expected to be exactly comparable either, as reduction in thickness is plotted as against reduction in cross-sectional area. In the case of sheet-rolling, lateral spread of metal takes place, whilst such is not the case in wire-drawing. The lateral spread is, however, proportional to the reduction in thickness.

The curve for elongation shows an inflection at the stage corresponding to the change in rate of increase of tensile strength, but it is less strongly marked.

It would appear, however, that the object of the author has been achieved, viz., to show whether the change of state shown by Alkins occurs with pure copper containing no determinable oxygen, and in sheet-rolling as well as wire-drawing. It has been shown that the change does occur in copper which has been progressively cold-rolled without annealing, and that cuprous oxide plays no fundamental part in the phenomenon.

It is also of great interest to note, in cold-rolling pure copper, how great may be the severity of the treatment without the malleability being destroyed.

The last pass produced sheet measuring less than $\frac{1}{1000}$ in. thick, and probably this could, with care, be reduced still further. The author was informed by Mr. G. Bird, of Messrs. A. Kemp and Sons, Birmingham, by whose courtesy the rolling was carried out, that ingots of pure copper 1¼ in. thick have been successfully rolled down to 0·002 in. without annealing.

Hardness Tests.—Hardness tests have been made by the Brinell method, by the auto-punch method (as devised by H. L. Heathcote of Coventry), and by the scleroscope method.* It will be seen from the figures given in Table II, and from the curves plotted therefrom in Fig. 2, that the Brinell method does not indicate a marked change in hardness values to correspond with the change indicated by the tensile tests.

TABLE II.

No.	Thickness.	Condition.	Per Cent. Reduction in Rolling.	Diameter of Auto-punch Depression.	Brinell Hardness No.	Scleroscope Hardness No.
	in.					
1	—	Slowly cooled from fusion	—	2·35	36	4
2	0·5	Forged hot and annealed	—	1·91	52	6
3	0·309	1st pass ..	31·8	1·8	86	23
4	0·244	2nd pass ..	46·13	1·75	91	22
5	0·168	3rd pass ..	62·9	1·75	100	28–29
6	0·103	4th pass ..	77·2	1·70	105	47
7	0·088	5th pass ..	80·57	1·64	109	40
7a	0·079	5th pass ..	84·3	1·56	—	—
8	0·075	6th pass ..	83·44	1·50	—	48
8a	0·066	6th pass ..	86·5	1·51	—	—
9	0·057	7th pass ..	87·4	1·41	—	48
9a	0·055	7th pass ..	89·0	1·36	—	—

There is a change indicated in the auto-punch figures, but less marked and having a wider range than that in the tenacity-reduction curve (Fig. 1).

It will be noticed, however, that a very sharp change in direction of the curve occurs at about 80 per cent. reduction, corresponding to the second step in the tenacity and elongation curves, and to the promise of a similar change in the Brinell hardness curve.

The thickness of the metal in the thinner gauges is probably insufficient to enable the Brinell figures to be accepted as trustworthy, nor was there a sufficiency of metal left in the thicker gauges to enable a reliable number of check tests to be made.

For the auto-punch tests it was found desirable to use, as an anvil, material of the same degree of hardness.

* Price and Davidson (Transactions of the American Institute of Metals, 1916, vol. x, page 142) indicate that there is a change in the rate of increase of scleroscopic hardness of common brass when cold rolled, at about 50 per cent. reduction.

By this means greater uniformity of results was obtained, the copper test strip resting, during test, on a strip or strips representing the same degree of reduction as that of the test strip. The author suggests that this method might be serviceable when testing sheet metal by scleroscope.* The scleroscope tests show a marked change at about 50 per cent. reduction, and an abrupt change of direction at 80 per cent. reduction.†

Tests on the Annealed Series.—A number of strips were close annealed at 750 deg. C. in a sheet-iron box filled with asbestos fibre, thin sheets of mica being used to separate the specimens from one another. The annealing period was 15 minutes, 10 minutes being allowed for the box and its contents to come up to the temperature of the muffle.

The temperature was indicated by a platinum-platinum-rhodium thermocouple in conjunction with a millivoltmeter, the combination having been previously calibrated with pure metals of known freezing points.

The test results are given in Table III and plotted in Fig. 3. The interesting feature of these tests is that a sharp change in direction takes place at about 80 per cent. reduction, the maximum stress rising and the elongation falling. The yield-point figures, although untrustworthy, owing to the shortness of the specimens, show a distinct rise, commencing at the same point. It would appear, therefore, that when pure copper is rolled progressively, at a stage representing about 80 per cent. reduction in thickness, softening ceases to be complete under the annealing conditions specified. Whilst this fact may be of little importance to sheet manufacturers, owing to questions of increased power and diminished speed of rolling, ruling out the possibility of reduction of so great a degree of severity being performed in works practice, it may not be without interest to wire-drawers. The papers by Pye‡ and Alkins§ indicate that the reduction of area in progressive cold-drawing must exceed 80 per cent. in order that copper wire may meet certain Post Office specifications. Should such wire fail to meet the specification and be required on this or any other account for some other purpose involving subsequent work, it will require special annealing treatment.

It will be noticed that there is no marked step in the curves of the annealed series at about 50 per cent. reduction to correspond with that found in the unannealed series. This does not mean that no such step occurs, as sufficient material was not available for tests representing the first two passes. Probably, however, no such step does occur, the gradient being a very easy one up to 80 per cent.

Reverting to the tensile tests on the unannealed series, it should be pointed out that yield points were taken on the strips (by means of dividers), and it was found that after the first pass (31·8 per cent. reduction) the yield-point nearly coincided with the tensile stress.

At the fourth pass (77·2 per cent. reduction) a yield was noticed at 25·19 tons per square inch (0·29 ton lower than the tensile stress), and again at the sixth pass (83·4 per cent. reduction) a yield occurred at 26·45 tons per square inch (0·45 ton lower than the tensile stress). Beyond this point it was not possible to differentiate yield-point from maximum load.

Price and Davidson‖ found in testing longitudinal specimens of progressively cold-rolled brass (64·71 per cent. copper), that yield-point and tensile strength coincide at 42 per cent. reduction in thickness. The curve for yield-points would consist of two straight portions, separated by a curve, but instead of having a different value from one another, the two parts would be practically parallel to each other, if the step at 80 per cent. reduction be ignored, and only the general trend of the upper part be regarded.

The effect of considering the hypothetical yield-point curve in this light is to throw into greater prominence the change in direction at 50 per cent. reduction. Moreover, the two parts of the curve represent the strength of the material (approximately) without change of sectional area. It would almost seem as though the range of reduction covered by the first step in the curve represents a change-over from material, the strength of which is mainly due to the intercrystalline amorphous phase, to material the strength of which is mainly due to the intracrystalline amorphous phase produced by the rolling treatment.

It is an interesting speculation to consider what would be the shape of the tensile stress-reduction curve if the tensile stress figures were calculated on the area of the specimen under stress at the maximum load.

It would be found that the first half of the curve would be far less steep than it now is, and of course higher up. The explanation of the change in direction might be bound up with the quality of the deformational treatment up to the maximum load.

The first part of the curve would represent material in which the intra-crystalline amorphous phase had been produced, partly by constrained "flow" (rolling) and partly by unconstrained "flow" (simple pulling), the rise in the curve being due to the increasing quantities of amorphous phase produced by rolling. The second part would represent material in which the amorphous phase was produced practically entirely by the rolling action.

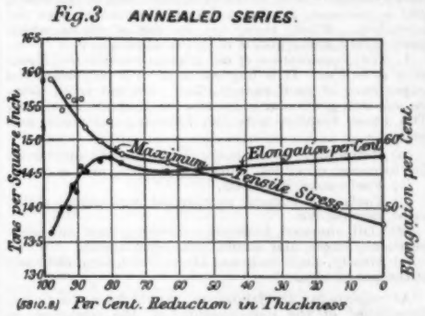
TABLE III.—*Strips Annealed at 750 Deg. C. for 15 Minutes.*

No.	Thickness.	Condition.	Maximum Stress. Tons per Sq. In.	Elongation Per Cent. $l = 4\sqrt{\text{area}}$.	Hardness.	
					Auto-Punch. Diam. of Depression.	Scleroscope. No.
	in.					
1	—	Slowly cooled from fusion	8·88	45·0	2·35	4·0
2	0·453	Forged and annealed	13·725	57·8	1·91	6·0
		Annealed—				
3	0·309	1st pass ..	—	—	—	—
4	0·244	2nd pass ..	—	—	—	—
5	0·168	3rd pass ..	14·66	55·3	2·15	12·0
6	0·103	4th pass ..	14·79	55·75	2·07	14·0
7	0·088	5th pass ..	15·27	57·2	2·08	16·0
8	0·075	6th pass ..	14·97	56·8	2·10	16·5
9	0·057	7th pass ..	15·16	55·1	2·0	14·0
10	0·050	8th pass ..	15·58	55·5	—	14·0
11	0·044	9th pass ..	15·55	52·2	—	14·0
12	0·034	10th pass ..	15·64	50·0	—	13·0
13	0·024	11th pass ..	15·44	50·0	—	12·5
14	0·015	12th pass ..	—	—	—	—
15	0·010	13th pass ..	15·88	42·8	—	15·0
16	0·0075	14th pass ..	—	—	—	—

The photomicrographs (Figs. 4 to 12, on page 440) show the influence of the rolling treatment on the structure, the crystal grains becoming distorted at first and then gradually lengthened and flattened.

As already shown by Mathewson and Phillips, in the case of cartridge brass, the first indication of deformation observable in the microstructure are given by the

Fig.3 ANNEALED SERIES.



curvature of twin crystals. These indications are succeeded by the appearance of deformation lines or "etch-bands" in the crystal grains themselves. It seems clear that the operation of continually rolling in one direction brings into service those gliding planes whose lines of intersection with the face of the rolled strip coincide with the "etch-bands," which run generally at right angles to the direction of elongation of the grains.

The gliding planes themselves may form almost any angle with a plane parallel to the face of the strip, as may be seen by examining a vertical longitudinal section.

Owing to this selective employment of favourably-situated slip planes, the remaining slip planes undergo such relatively light displacement, that no "etch-bands" appear as evidence of their existence.

Price and Davidson have shown that transverse specimens of severely rolled brass possess different mechanical properties from those of specimens representing the same degree of reduction, when tested longitudinally.

The yield-points of the former are usually much lower than those of the latter, indicating that, in a lateral direction, the slipping planes have not been called upon to undertake such heavy service as those in a longitudinal direction.

The "etch-bands" of the latter are strongly pronounced, apparently because of the production of a comparatively excessive amount of the amorphous phase, the solution tension of which is so much greater than that of the intervening crystalline layers.

The "etch-bands" appear to become, if not more numerous, yet more in evidence as the severity of the reduction increases. As pointed out by Mathewson and Phillips, the effect of their appearance is to reduce the contrasts between crystal grains which are produced by contrast etching.

The author cannot do better than quote their description of this effect:—

"When a specimen of rolled brass showing lines of deformation is manipulated under the higher magnification, it is seen that the black lines are shade effects, primarily due to differential etching of the surface into curved elements of varying breadth and elevation. The surfaces of intersection of neighbouring elements reflect the incident rays away from the line of vision, producing dark bands, whose breadth and quality vary with the focusing position and the angle of illumination. Where the original orientation of the grain is such as to reflect very little light to the eye, i.e., in the case of a dark grain the deformation detail may yet be seen to some extent, since part of the light reflected from the curved surfaces of intersection between bands reaches the eye. Thus the light bands as a whole are rendered darker, while the dark grains are rendered lighter, so that the original contrasts are greatly reduced."

MICROSTRUCTURE OF THE ANNEALED SPECIMENS.* The microstructures showed that the grain size diminished with severity of reduction. Two typical photomicrographs are shown in Figs. 13 and 14, page 440. In the latter it will be noticed that recrystallisation is incomplete, an elongated grain having only partly recrystallised. In this specimen the microstructure still revealed the direction of rolling. The results of the tensile and hardness tests are thus confirmed.

In another series of annealed specimens (at 600 deg. C. for 30 minutes), the slower rate of recrystallisation of the severely-reduced strips was shown by tests (Table IV) to an even more marked extent than at 750 deg. C., whilst in yet another series annealed at 800 deg. C. it was less marked.

TABLE IV.—*Strips Annealed at 600 Deg. for 30 Minutes.*

No.	Thickness.	Per Cent. Reduction in Rolling.	Yield-Point. Tons per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation per Cent. $= 4\sqrt{\text{area}}$.
5*	0·168	62·9	3·05	15·04	50·0
6	0·103	77·2	3·59	15·7	56·7
7	0·088	80·57	3·9	15·7	55·8
10	0·050	80·96	6·17	16·0	54·7
11	0·044	90·28	6·56	16·5	53·5
12	0·034	92·5	6·76	16·4	51·3

* Taken from near edge.

The author has much pleasure in placing on record his best thanks to Mr. G. Bird, of Messrs. A. Kemp and Co., Birmingham, for affording facilities for the rolling of the strips, and to Messrs. A. Thomas and W. N. Smirles, of the author's staff, for assistance in making the tests.

ROAD TRANSPORT WHITLEY COUNCIL.—The first meeting of the Joint Industrial Council for the Road Transport Industry was held in the Council Chamber, Middlesex County Council, Middlesex Guildhall, Westminster, S.W. 1, on March 11, 1919, under the chairmanship of Mr. G. J. Wardle, C.H., M.P., Parliamentary Secretary to the Ministry of Labour. A very representative gathering of delegates of employers' organisations and trade unions was present. The following are appointed officers of the council: Mr. G. A. Dutfield, J.P. (National Alliance of Commercial Road Transport Associations and Federations), chairman; Mr. E. Bevin (National Transport Workers Federation), vice-chairman; and Mr. G. T. Tuke (National Union of Horse and Motor Vehicle Owners' Associations), treasurer. The joint secretaries are: Captain F. G. Bristow (general secretary to the Motor Transport Employers' Federation), 83, Pall Mall, London, S.W. 1; and Mr. F. J. Maynard (National Transport Workers' Federation), 8, St. Martin's-lane, Trafalgar-square, W.C. The constitution of the council was considered and adopted, and many matters of interest to the road transport industry discussed.

INSULATION RESISTANCE OF PORCELAIN AND ERINOID.—In the Scientific Proceedings of the Royal Dublin Society, Dr. R. G. Allen describes, in three papers of 1918, experiments on the electric resistance of porcelain and of erinoid. The porcelains examined at temperatures between 80 deg. and 300 deg. C. were: (*a*, *b*) Two low-tension insulators, 0·7 cm. and 0·65 cm. thick; (*c*) an old insulator of 1862, 0·65 cm. thick; (*d*) an evaporating dish, 0·22 cm. thick, German; (*e*) a tube of Berlin porcelain, 1·1 c.m and 0·8 cm. diameters; (*f*) a crucible lid of German make; (*g*) a bowl of Portland china, 0·22 cm. thick; (*h*) and an evaporating dish of Royal Worcester, 0·16 cm. thick, all glazed except the inside of the tube. The results confirm the formula which Rasch and Hinrichsen gave in 1908 for the specific insulation resistance: $\text{Log } \sigma = \frac{a}{T} \times b$, where a and b are constants and T is the absolute temperature. The resistance at 10 deg. and 40 deg. C. were: (*a* and *b*) 1,590 and 40 megohms per cubic centimetre; (*g* and *c*) 3,980 and 158; (*d* and *e*) 11,200 and 250; (*h*) 200,000 and 6,300; (*g*) 500,000 and 10,000 megohms. For temperature above 250 deg. the resistance was generally independent of the voltage, but the different porcelains differed largely. The formula stated was also found to hold for "erinoid," which is described as a by-product of milk, and for red vulcanised fibre up to 110 deg. C. Erinoid was found to be slightly hygroscopic, but less so than the fibre; red erinoid (it is supplied in various colours) absorbed most water; in any case the resistance of erinoid decreased slowly in moist atmospheres. Erinoid was also superior to the fibre, however, as to dielectric absorption. The break-down voltages were fairly the same for the two materials, 10,000 volts to 16,000 volts in well-dried samples of 2 mm. thickness. The special experiments on moisture absorption confirm the view of Rasch and Hinrichsen that the electricity is conducted through insulating materials by the aid of the moisture films.

* In one instance the author has found that, by superimposing hard-rolled copper strips (0·01 in. thick) in a similar strip, the hardness was five points lower on the scleroscope scale than when the strip rested on the bare anvil.

† The author is indebted to Mr. H. H. Hayes for his kindness in making the scleroscope tests.

‡ "The Mechanical Properties of Hard-drawn Copper," Journal of the Institute of Metals, No. 2, 1911, vol. vi, page 165.

§ "The Effect of Progressive Cold Work upon the Tensile Properties of Pure Copper," *ibid.*, No. 2, 1918, vol. xx, page 33.

‖ Transactions of the American Institute of Metals, 1916, vol. x, page 141.

* The author intends making an exhaustive examination of the influence of annealing on copper deformed to various extents. Work of much value in this connection has been carried out by Mathewson and his collaborators (*vide* Transactions of the American Institute of Mining Engineers, vol. lv., 1916; also *Internationale Zeitschrift fur Metallographie*.

THE RELATIONSHIP BETWEEN THE LABORATORY AND THE WORKSHOP.*

By W. R. BARCLAY, Member (Sheffield).

THE word "laboratory" is usually defined as a "place where scientific experiments are carried out." But science, in the ultimate, is only the study of the forces of nature and the laws which govern these forces. Every branch of human industry, at its basis, is just the application of these forces and their laws to the supply of some need or luxury of human life. In other words, one may truly say that all industry is just "science applied." A laboratory is therefore, in fact, a workshop—in a different category from the shop of the blacksmith, the carpenter, the mechanic, or the plumber, but a workshop all the same. Indeed, the very word itself is derived from the Latin *laborare*, to labour, *i.e.*, to work. I desire to make this clear at the very commencement of what I have to say, for unless the fullest implications of this point are realised, we shall fail to arrive at a clear understanding of my main thesis.

Our subject of study is "The Relationship between the Laboratory and the Workshop." Let it be absolutely clear that the laboratory is itself a workshop, then I think we can proceed to a discussion of relationships without the possibility of ambiguity, for our study in the main is just that of the links of connection between what may be termed workshops, which differ only in their class, one being of necessity a little higher in the scale of development than the other. The key-word to my paper is going to be one which has been much to the fore lately—"co-operation." Let it be, however, perfectly clear that both the laboratory and the workshop have fundamentally the basis that gives this word any meaning, for one can never have co-operation except between things which have in essence (*a*) the same principles of operation and (*b*) the same objects of accomplishment.

First of all, then, I would spend a little time in the examination of the question: Are the principles of operation, and the objects of accomplishment, the same in the laboratory as in the workshop? At first sight it seems perhaps a little difficult to see this, but I am sure as one looks further and more deeply it will be seen that such is actually the case. What are the principles of operation in the workshop? As an illustration—seeing that most of us are interested in the metal trades—take a brass foundry and its operators. Their first requirement is equipment. Such equipment includes furnaces, flues, crucibles, fuel, mechanical tools and appliances, ingot moulds, sand moulds, and moulding machines, dressing compositions, and so on. Given equipment, what are the methods of operation? The more completely these are examined in detail, the more clearly does it appear that they are each one in essence nothing more nor less than the application of the laws of nature. A fire is started in the furnace in accordance with the laws of combustion; fuel is added, and higher temperatures are acquired, according to the same laws; the crucible is annealed according to the laws governing expansion and contraction of material, and the laws governing heat energy regulate the melting of the metal in the pot. An alloy is made in accordance with the laws of physical chemistry—the laws governing solutions of one substance in another. The alloy is poured, the casting is produced sound and ready for its further treatment. Again all is in accordance with fundamental scientific principles—the laws of liquefaction, of solidification, and of the behaviour of atoms and molecules. At all points in the series of operations negative precautions are intervened to prevent faults and failures. Why? Just because other laws are continually in operation which also need to be understood by the operators—forces which require intelligent control throughout if satisfactory work is generally to result.

Here, I think, I can imagine—if there are any workmen listening to me—the comment, "Well, I work in a foundry, but I know nothing about the laws of combustion, or of heat energy, or of physical chemistry." But I reply, "You do. You do not deny knowing how to obtain the best out of your furnace, how to get full value from your fuel, so that you do not use three times as much coke as you need to melt your 120 lb. or so of brass. You say, you know nothing of the laws of physical chemistry, of solutions, and so on. You do! You know how to make a solution of zinc in copper, otherwise you would never cast brass. You know a good deal about the laws of liquids and solids, or you would never get a sound ingot. You are a much greater scientist than you think. You are something of a mathematician, a chemist, a physicist, and a geologist. The laws of these sciences are your laws. You have no others; you can use no others; you can obey no others; and if you disobey any one of them, your work is a failure. These, in a word, are your principles of operation."

Turning now to the laboratory, I need hardly labour my point for a moment, for here, too, scientific principles of operation obviously apply. Works chemists, I am sure, will not deny the soft impeachment that they are scientists; that they seek to know and apply the laws of mathematics, chemistry, physics, and so on.

We will consider now my second point: Are the objects to be accomplished the same both in the laboratory and the works? Actually on this point there ought not to be the slightest question, but I am afraid there is a possibility of misunderstanding. The object of the workshop is production—production of work to be of use to the world at large or some particular section of it. Is the laboratory really in this class? I think I again hear the voice of my imaginary workman this time saying, that he has never seen anything that the laboratory produces; but if such a remark is made it is just because he has not yet a clear idea of what is the real purpose of the laboratory. I do wish to make clear to my colleagues, the workmen of mill and foundry, that the ultimate aim of the laboratory is production. And I desire to plead very strongly and earnestly for the recognition of that point. Laboratory and workshop are, fundamentally, links in the chain of production, and the future welfare of industry is entirely involved in the recognition of this fact. The strength of one is the strength of the other. We must have in this country in the future a much more cordial and whole-hearted realisation of this fact than we have ever yet had; and equally must the worker in the laboratory and the worker in the workshop realise the fact.

There being an essential sameness in the method of operation in both laboratory and workshop, this largely implies likeness of objects. But complete realisation of their true relationship involves an estimation of their comparative position and, therefore, differences. I have used the illustration of the links of a chain, but links make up a useful chain only if they are so completely related to each other that they reinforce each other's strength. If links are simply placed in parallel they are not a chain and will not do the work of a chain To use the well-known terms of electric circuits—the laboratory and workshop are not in parallel, they are in series, and the motive force of each is added to the other. At the same time they are by no means identical, and it is in their differences that the real nature of their relationship is made clear.

What are the duties of a laboratory—particularly a works laboratory? Much of what has already been said is obviously applicable to laboratories in general, including those of technical colleges and universities, but these latter have teaching duties which are not directly related to works practice. Many laboratories also have duties of a judicial character, with which, again, we are not immediately concerned. These are all, in their specific way, links in the chain, but it is the works laboratory which comes nearest to the productive end of the series, and is obviously in the most intimate contact with the workshop. What, then, are its duties—those which particularly distinguish it from the workshop?

1. *The Examination of all Materials which the Workshop is to Use.*—It is impossible to over-emphasise the importance of such examination. Let me again draw on our own particular industries for illustrations of this. The brass founder uses the following materials and tools:—

(*a*) Refractory materials, *i.e.*, heat-resisting substances for furnaces, crucibles, annealing muffles, and so on.
(*b*) Fuel—coke, gas or oil.
(*c*) Tools and general mechanical appliances—chills, ingot moulds, &c.
(*d*) Oil, charcoal, plumbago, moulding sand and compositions, fluxes, and mould-dressing materials.
(*e*) Finally, the metals and alloys which form the basis of the production.

As regards (*a*), the laboratory should have the fullest knowledge of the requirements of the workshop in the direction of refractory materials. It should therefore regularly examine and report upon the suitability of all purchases in this direction. Further, it should supplement its own knowledge of the subject by keeping careful records of the behaviour of all such materials in the practical routine of the workshops' experience, and examine, not necessarily with the object of the rejection of those considered unsuitable, but in order to keep proper records of them so as to render it possible to trace their subsequent effects on the workshop's experiences.

Similarly, with regard to (*b*) *Fuel*. Regular examination should be made by the laboratory of the calorific value of all fuels used, whether coke, oil, or gas. Particularly should it examine them for those subtle impurities that every now and then, as all metallurgists know, are imported to the molten metal by the fuel with most deleterious results.

(*c*) A consideration of the item of tools and general mechanical appliances, ingot moulds, &c., brings us into rather a different sphere, but here again I contend the laboratory should exercise a vital control. The items under this heading open up a most fruitful field to the laboratory worker, and one that hitherto has been very barely tilled. My ideal laboratory would have a subsection specially devoted to the subject of the efficiency of tools and mechanical appliances. It would involve the addition to the staff of a trained engineer, but I am sure it is worth while. In very many branches of industry, but in general foundry practice particularly, an enormous amount of physical labour is expended very inefficiently. I would have this section continually overhauled, all operators being observed by a trained mind and an outlook continually kept for increased possibilities of efficiency.

The position of labour requires our special consideration in this connection. I think that there can be very little question that wages will remain at least at their present level after the declaration of peace. There will be no return to cheap labour in any event. But obviously, if there is to be increased means of spending, on the part of our population, the elementary principles of economics demand that there must be increased production. The wealth of a country does not lie even in its gold reserves, much less in its circulation of notes and cheques; any government can increase the circulation of currency by setting in motion printing-presses. Admittedly the wealth of a country lies entirely in its power of production, whether it be in agriculture or manufacture, and so far as this country is concerned, while we may—and I hope we shall—very materially increase our agricultural productions, our future hopes and prosperity must depend much more largely on our manufacturing productivity. Ultimately this resolves itself into an increased product per unit of labour. In some of the more efficient sections of the Ministry of Munitions, most interesting and valuable tabular statements have been collected, showing in certain branches of munitions work the relative number of workpeople respectively employed in different firms to obtain the same output. These statements have revealed most striking disparities, and make it very evident that the human factor in production is by no means economically used even by large and otherwise successful industrial firms. If the actual wealth of the community is to be at all on a par with its present artificial wealth, we must not have 10 men engaged in producing an amount of work which scientifically ought to be done by five or six. It is to be earnestly hoped that the war, and our experiences during it, has put an end for ever to the fallacy about labour being injured by increased mechanical efficiency.

Returning now to the more strictly scientific side of our subject, I would revert to the subject of tools and appliances, and, thinking particularly of the foundry, of ingot moulds. At first sight it does not appear that the laboratory staff has much to do with an item like this, but let us look more closely as to what is involved.

The subject of the production of sound ingots and castings in steel has recently received consideration in the Journal of the Iron and Steel Institute, where there has been published a remarkable and eminently practical series of papers by scientific steel experts—notably Hadfield, Brearley, Kilby, and others. All these papers are well worth study, but I particularly desire to mention one by Mr. H. Brearley of Sheffield. In a most interesting series of experiments with molten stearine, this author has vividly illustrated the manner in which material well into the liquidus temperature solidifies when poured into moulds, and has thereby thrown considerable light on the subject of the production of sound ingots. These experiments reveal clearly the importance of a study of the shape and size of ingot moulds. The following are some of the factors which influence the quality of an ingot casting:

(1) Length of mould.
(2) Design and shape of mould.
(3) Thickness of wall of mould.
(4) Accuracy of fitting.
(5) Position of mould during pouring of ingot.

All these factors (except the last) are constant with every set of moulds. These, clearly, are matters demanding the attention of the trained and observant minds who should form the laboratory staff.

Coming now to (*d*), oil, charcoal, plumbago, moulding compositions and sands, fluxes, and what may be termed the general chemical materials of the foundry, there is no need to labour the point of the necessity for laboratory control here. But the laboratory should supervise not only the quality of all such materials, but also their quantity. Here is a very fruitful field in which to obtain a much higher degree of efficiency and economy.

Lastly, under (*e*), I come to the question of the examination of all metals and metallic alloys which form the basis of the foundry products. In most works laboratories this is so clearly defined a function that no elaboration of its necessity is needed. At the same time, I would like to call attention to the highly valuable knowledge and experience which may be derived from more complete work in this direction. Commercial metals always contain impurities often present in only very small quantities, in many cases indeed only traces. The works chemist, therefore, has often the opportunity of obtaining data as to the behaviour of these, and of observing the effect of certain specific cases, in a much more extensive fashion than can be done in the laboratories of universities, technical colleges, and in private practice.

2. *The Examination of all Outgoing Products of the Workshop.*—Here we have the second division of the duties of the laboratory. The laboratory should be always the final court of appeal on standards of quality. I know that this is a difficult doctrine to preach, and a still more difficult one to practise. All kinds of commercial, financial, and political questions arise. By making all allowance for these, I still contend that if the laboratory is in its true position in the works, it should decide upon and hold the standards of quality. I admit that this demands, on the part of the laboratory staff, a considerable degree of practical knowledge. Probably the laboratory chief has not, and cannot be expected to have, a complete all-round practical knowledge of every process in the particular works to which he is attached. In that case, however, he must have on his staff specialists in the works processes, and in all cases where an inspection staff is a recognised section of works organisation that staff should be under the general administration and direction of the laboratory. Special emphasis is laid upon this point because here so very largely lies the possibility of progress.

A thoroughly well-organised works possessing vitality and the spirit of progress is one of the most valuable assets that any country can possess. Such works will be of incalculable value in the future and as we begin the struggle for industrial supremacy; and such a works will possess a highly developed technical and scientific staff which, by virtue of its training, is instinctively on the lookout for possibilities of improvement. Such possibilities abound in every branch of industrial production.

3. *The Laboratory should Act as the Works Intelligence Department.*—The aggregate knowledge of the world is steadily increasing every day. Not a day passes but a little further knowledge is garnered from "Nature's infinite book of secrecy." But the value of knowledge lies in its application. The laboratory is the natural—

* Paper read before the Institute of Metals, on Wednesday, March 26, 1919.

and, indeed, in the great majority of cases, the only—medium by which the increase of scientific knowledge is made available for the works use. As an illustration in point, in the year 1801 the existence of a new element, vanadium, was discovered. A small piece of additional knowledge had been garnered. Thirty years later the element itself was isolated, but for sixty-six years little or no use was made of it. In 1867, Sir Henry Roscoe made a relatively exhaustive study of vanadium and its compounds. A further period of nearly thirty years elapsed. Then one day two technical enthusiasts walked into Professor Arnold's laboratory, in what is now the University of Sheffield, with samples of ferro-vanadium and marvellous theories as to its influence in steel. Fortunately for England, the Sheffield laboratories were Intelligence Departments in the true sense, and very speedily the workshops of Sheffield were hard at work manufacturing high-speed steel for the world. But—here is the moral of the story—had there been no Intelligence Departments, that little bit of knowledge which Del Rio in 1801 and Roscoe in 1867 rescued from Nature's storehouse would have been of little or no practical value whatever in the present world's work and experience. But not only should the laboratory be the Intelligence Department for outside sources of knowledge but also for inside sources. Are there not immense possibilities of discovery in a patient and systematic study of the processes which go on every day in the factory? I am quite sure that much valuable knowledge, obtained often accidentally by workmen, is lost to the world because it has not been observed and recorded by trained minds. Indeed I know of few more fruitful fields of knowledge than a foundry, or a workshop of a similar class. I consider, sometimes, that it would be a delightful holiday to be able to sit down quietly in the corner of a foundry every day for a week and do nothing but observe and record. I am quite sure it would not be only a holiday, but a very productive experience, if one's observatory powers were well developed. On this point also may I tentatively suggest that the laboratory might be called in occasionally to study the question of costs—particularly where cost items are a variable quantity. It is no uncommon experience, *e.g.*, for a works manager to find that appreciably more time is occupied on some days over a particular operation than others. A scientific study of conditions will often throw considerable light on problems of costs and efficiency as well as on problems of quality. Still further, the laboratory as an Intelligence Department should be continually alert, not only for new scientific knowledge, but for improvements in technical details of production. It should be ever asking the question, "Are our works methods up to date?" "Are we keeping abreast of possibilities?" "Are we turning out our work under such conditions of manufacture as tend to high standards of quality?" Often the very asking of such questions intelligently yields their own answer.

In drawing this rather discursive paper to a conclusion, I would deal with a part of the subject which is the most difficult of all. I refer to the human factor. At the beginning of this paper I stated that the key-word of what I had to say was co-operation. I have tried to point out throughout my remarks that the relationship between the laboratory and the workshop should be that of two sections or links of one chain, each supplementary and complementary to the other. My whole outline of the duties of a laboratory depends upon the degree to which this ideal is made practicable. But how is it to be done? I have had considerable experience, hearing much of both sides, and I am compelled to come to the conclusion that the present position of affairs is by no means altogether healthy or satisfactory. Far too often the laboratory and the workshop are divorced. In some cases (unfortunately not a few) the workshop has learned to regard the laboratory as its antagonist, or at any rate its "critic in chief." Now obviously there must be criticism; and not only on the part of the laboratory, for I have known some workmen who were able to offer very intelligent criticism of the laboratory's work. And this is healthy; but do let us make a most serious and earnest effort to obtain the clear atmosphere of co-operation in which only is criticism of any real value. The following illustration from my own experience indicate what I have in mind:—

Some years ago I had, amongst other duties, to undertake the control of a small foundry where nickel and copper alloys were made. I found that a number of rather serious faults were common in the productions of this foundry. A short investigation showed that some at least of these troubles could be remedied by the use of deoxidants. Here, however, the human element entered in. The head caster—a man over sixty years of age—was violently prejudiced against scientific methods. It would have been sheer folly to give him a mysterious packet with instructions to put it into the pot 10 minutes before pouring. I should never have been sure of results. I therefore studied this human factor. As a result I spent two or three afternoons in giving my caster some very simple lessons in metallurgy. I aimed at first at nothing more than interesting him. This I succeeded in doing so thoroughly that when I came to the subject of deoxidants it was the easiest thing in the world to lead him on to himself making suggestions as to their use. I am glad to say this man quickly became an enthusiast for progressive methods, and I need hardly add that I also learnt from him; our collaboration only ended by his death.

This is an instance of what I mean by co-operation. To the works chemist I say, "Take the workman into your entire confidence." If he is what I believe most workmen to be—honest and reliable—you will be amply rewarded for any trouble you may take. Discuss methods with him, and above all encourage him to make suggestions.

Labour is going to take a much more prominent part in the management of industry than before the war. Some business men, indeed, prophesy that we shall have Labour Boards of Directors. That is probably a little extreme. Whatever direction this increased share of labour in business management will take, however, one good thing at least will result—that labour will begin to realise the difficulties of works management and control. And whatever be our opinions as to the advantages or disadvantages of this movement of labour, if we are worthy citizens of the Empire we must endeavour, each in our own sphere, to steer, in so far as we can, such movements into a healthy channel.

I am quite convinced that the scientifically trained man, if he will exercise reasonable tact, judgment, and diplomacy, will be able to do better work on these truly educational lines than all the politicians in the House of Commons. A thoroughly efficient, well-managed works laboratory, with a keen, trained, sympathetic, and tactful staff, has tremendous possibilities in this direction of helping the workman to realise the responsibility of his job, and the possibilities latent in it. And the whole secret of success in handling workmen is to get them to take a thorough and intelligent interest in their job. This is the work of the technical expert rather than the manager. As a rule the latter is overwhelmed with details of commercial management—the position of the order-book, the thousand-and-one points of office and business management which every day brings. It is the laboratory chief and his staff who are best able to do such work as I have indicated here.

And I am sufficiently optimistic to believe that sooner or later we shall develop on these lines—in spite of the dark outlook that sometimes appears—as we read and hear of strikes and syndicalist movements, and general industrial unrest. After all, the world will go on, and the continuance of life depends upon the continuance of production, and wars or no wars, revolutions and counter-revolutions notwithstanding, we must hammer out some system for the carrying on of industry.

As I conclude I would emphasise the fact that the young technical man of to-day has a great life before him. It will mean work, hard work, but at least it will mean living and not rusting. And experience shows that the joy of life lies in the full use of it.

PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on Friday, February 28, at the Imperial College of Science, Professor C. H. Lees, F.R.S., President, in the chair, a paper "*On Simplified Inductance Calculations, with Special Reference to Thick Coils*," by Mr. P. R. Coursey, was read, in the absence of the author, by Mr. J. Nicol. The method of calculation in the paper is based on an extension of Nagaoka's formula for single-layer coils, to include as well all ordinary forms of thick coils. Rosa's formula for thick coils is put into the same form as Nagaoka's, and its use enables a series of correction factors to be calculated for various coil thicknesses. By the aid of a single sheet of curves giving values of these correction factors the inductance of any form of coil likely to be met with in practice may be readily calculated, using only one simple standard formula for all cases. Reasonable accuracy is obtained even in the limiting example of a single turn of wire. The results arrived at agree well with other published charts, which are usually of more limited application, while the use of a single formula for all cases lessens the liability to error.

It is also shown that Raleigh and Niven's formula enables the calculation of the correction factors for very short coils to be carried out without having recourse to Nagaoka's more complicated expressions.

Discussion.—Dr. Eccles said that as the author had mentioned an abac given in the speaker's book on "Wireless Telegraphy," it was well to remark, first, that this abac was deliberately made of its present range so as to provide an open scale for coils of the proportions used in practice. For the rare cases of coils outside the range of the abac very simple formulæ are available. Dr. Russell's formulæ were used in making the abac, because they seemed more convenient for the purpose than the results of Nagaoka, to which they were, of course, equivalent. By constructing new curves for dealing with coils of several layers the author has rendered a great service, and has opened easy paths through a forest of laborious theoretical calculation. Now that this has been done it will be much easier to compare the measured values obtained on actual coils with the calculated values, and so we shall be aided to accumulate experience of the effects of high frequency eddy currents on the inductance of coils.

Professor Howe agreed with Professor Eccles' remark about the general utility of Mr. Coursey's investigation. The chief differences between the author's curves and those of the Bureau of Standards was that in the latter the ratio D/l and k, which was a function of D/l, were combined into a single function.

Mr. Nicol, in reply, referred to formulæ published in *The Electrician* by Mr. Coursey a few years ago, and considered that the step now taken, which resulted in restricting the values of k to between 0 and 1, combined with the general inclination of the curves to about 45 deg. with the axis, gave much greater convenience in reading.

A *Demonstration of Some Acoustic Experiments in Connection with Whistles and Flutes* was given by Dr. R. Dunstan. Experiments were made with hollow spheres, cylinders and cones with holes of various sizes and in various positions. Bernouli's theorem, which gives the wave-length of the sound produced by a cylindrical pipe in terms of the length of the pipe and an end-correction depending on the diameter only, was shown to be quite inadequate for practical purposes, the pitch depending on many other factors, such as the wind pressure, the size and shape of the blowhole, &c. Cylindrical flutes appear to require an end-correction which—within certain limits—is equal to D^2/d, where D is the diameter of the pipe and d the mean diameter of the mouth hole (which is often oval in shape). In the shortest flute experimented with, which was only ¼ in. long, Bernouli's theorem would give the wave-length as 2 in., whereas it was actually 14 in.

The conclusions drawn from the experiments are that in blowing across a hole in a hollow body a force existed on an elastic substance. The result is a "spring back," which produces an aerial throb, puff or pulsation. The frequency of the pulsation is determined by relations between the dimensions of the instrument, the size of the hole, the wind pressure, &c. Any resulting sound has its wave-length determined by the frequency and not primarily by the dimensions of the instrument, as in the usual text-book treatment.

Discussion.—Professor Bragg referred to Lord Rayleigh's work on open pipes and flasks, and said that since the internal pressure of the air would vary with the size of the aperture, it was easily conceivable that a difference of pitch would result when a change was made in the size of the aperture. Mr. F. J. W. Whipple outlined Lord Rayleigh's explanation of the long wave-length of the notes obtained from a hollow sphere. Mr. T. Smith asked if the variation in pitch with the position of the hole along the cylinder had been fitted to a formula—for instance, was the change in pitch proportional to the square of the distance of the hole from the centre of the cylinder? Mr. Nicol spoke of the end correction, and stated that students often applied the correction to the closed end of pipes, which was incorrect. Mr. F. E. Smith said the end correction was useful in electrical problems, and gave an illustration of the variation of D^2/d in an electrical case.

The president asked if there was much variation in the ratio D/d, and said he thought the formula was important if it could be verified over a wide range. He referred to Lord Rayleigh's experiments on flasks as closely analogous to those of Dr. Dunstan. In reply, Dr. Dunstan stated that the range of D/d was not very large in the instruments he had used.

A *Demonstration of a New Polariser* was given by Mr. G. Brodsky. In the course of experiments with polarisers built of piles of glass plates disadvantages due to bulkiness of the apparatus and loss of light had to be overcome. The idea occurred to him to place the pile of plates between two prisms of the same glass in such a manner as to:—

(a) Reduce the length of the polariser by one-half;
(b) Utilise the full aperture of the pile; and
(c) Get rid of all reflected light.

Results obtained with experimental prisms he showed were so good that they could be considered a very fair substitute for Nicol prisms of corresponding size, and the very small amount of light escaping through crossed prisms (which could be reduced further by additional plates) is for most purposes negligible. There would be no difficulty in building such polarisers to any required size, as all the material consisted entirely of glass in unlimited quantities and at reasonable price, and it was hoped that this invention (British Patent 121,906) would be used for many purposes. Polarisers for directly transmitted light were hitherto very scarce and costly, so that many uses they could be put to remained undeveloped (such as stereoscopic kinematography). The new polariser could also be adapted to advantage in microscopes, saccharimeters, optical pyrometers, &c., and used for optical benches in the lecture room. Experiments with piles of glass plates showed a very large discrepancy between the calculated and observed angle for best extinction. Whatever the glass used, and whatever the quality of the surface, this discrepancy came consistently to some 10 deg., whereas thin microscope cover plates were found to be useless. There seemed to be still an interesting field for investigation as to the conditions affecting the surface of glass plates used in polarisers.

Discussion.—Mr. T. Smith said it was difficult to discuss the merits of various forms of polariser, as many forms had been proposed and much was of a confidential character. He had been struck by the presence of two opposite tendencies in constructing such apparatus. In one group the optical portions of the apparatus were made large, and efforts were directed to increasing the size; in the other group where the attainment of the same ultimate object was in view these parts were made as small as possible.

The president asked if it was not possible to get equally good results without prisms by reflection only. He thought prisms made the arrangement complicated. Mr. Brodsky, in reply, explained that he agreed with the remarks about reflection, but that his efforts were confined to transmission effects for a particular purpose.

WATER-GAS PRODUCTION.—Investigating the production of water-gas and especially the decomposition of steam by red-hot charcoal, J. Gwosdz (Verhandlungen Verein-Beförderung Gewerbefleiss, 1918, pages 33 to 45 and 55 to 70) finds that carbon monoxide can be produced at relatively low temperature when the coal contains very little ash. The first primary products are carbon monoxide and carbon dioxide in equilibrium percentages; at the surface of the coal, however, more CO_2 is produced by the interaction between the steam and the glowing coal, and this latter reaction depends not only upon the surface of the coal, but also on the ash contents.

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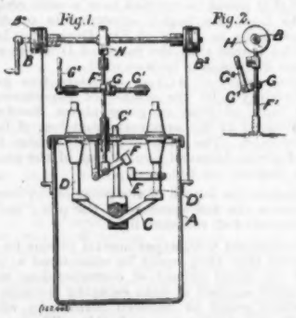
ELECTRICAL APPARATUS.

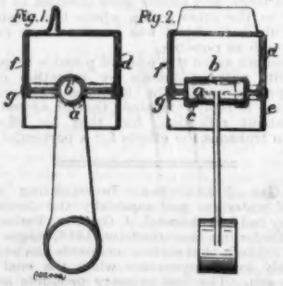
122,443. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, F. Coates, Cleadon, and J. Mirrey, East Boldon. Oil-Break Switches. (4 *Figs.*) January 18, 1918.—This invention relates to earthing devices for electric oil-break switches. An electric oil-break switch, according to this invention, is provided with one or more earthing members, so arranged and disposed that the conductors or contacts within the oil tank must be earthed before they are rendered accessible by the removal of the tank. The oil tank A is shown provided with raising and lowering gear operated from a shaft B. The isolating switch C contained in the tank is shown conventionally as operated by a rod C_1, and as is well known in oil-break isolating switches the mechanism for opening the switch C may be interlocked with the shaft B, so that the tank A cannot be lowered until the switch C has been opened. With this interlocking mechanism, however, the present invention is not concerned. Two conductors D, D_1 are shown passing through the fixed cover of the tank to the switch C, and one of these, D_1, is provided with a contact E, which may be connected to earth, *e.g.*, to the cover of the tank, when a pivoted contact arm F is moved downwards. Any convenient means may be provided for operating this arm F, but in the construction shown it is moved by means of a pin engaging with the slotted crank G on a spindle G_1 furnished with a handle G_2. To ensure that the earthing switch F



must be moved into connection with the contact E, thus earthing the conductor D_1, before the tank A can be lowered, interlocking mechanism is provided between the earthing switch and the tank-lowering gear. In the construction illustrated, this is shown as an engagement between the upper portion of the rod F_1 and a pulley-like boss H on the shaft B. The member H has a hole or recess in its periphery into which the end of the rod F_1 passes when it is in its raised position, and thus until the rod F_1 is withdrawn by partially rotating the shaft G_1 the shaft B cannot be rotated to lower the oil tank A. The movement of the shaft G_1 necessary to withdraw the rod F_1 from the member H causes the earthing switch F to move down and make connection with the contact E. The arrangement may be such that the contact between the members F and E cannot be broken, that is to say, the conductor D_1 must remain earthed until the tank is again raised. Obviously in the example illustrated this might be brought about by proportioning suitably the diameters of the pulleys B_2 controlling the vertical movement of the tank A. For if less than one revolution of the shaft B is necessary for the complete lowering of the tank, then the arrangement may be such that the rod F_1 cannot be returned into the hole or recess in the member H until the shaft B has been rotated back into the position shown in the drawings. (*Accepted February 5, 1919.*)

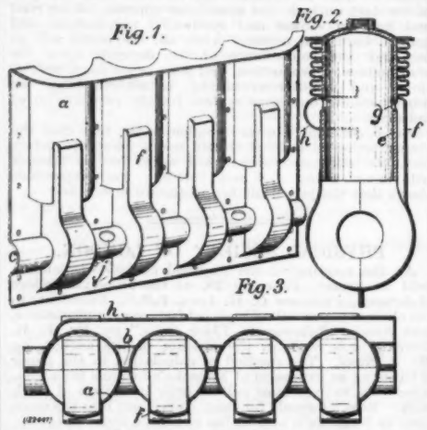
GAS ENGINES, PRODUCERS, AND HOLDERS, &c.

122,448. A. W. Wall, Sheldon, near Birmingham. Pistons and Connecting Rods. (3 *Figs.*) January 19, 1918.—This invention relates to a piston and connecting rod combination, in which the connecting rod is provided with an



external pivotal bearing surface adapted to co-operate with a female bearing surface provided in a stamped or equivalently-manufactured piston. The present invention comprises a combination having these characteristics, in which the piston is made up from parts formed by stamping, pressing or the like, that part of the piston bearing surface which functions, during the power stroke, being pressed, stamped or the like in one of the parts forming the piston body. The connecting rod is, at its one extremity, formed with two cylindrical projections *a*, *a*, the axes of which are located transversely to its length, these cylindrical projections being aligned with each other. The piston is divided transversely in a plane containing the axis of pivotal connection with the connecting rod. At this plane of division, semicircular concavities *b*, *c* are provided in the upper and lower parts of the piston. These semicircular concavities terminate at a suitable distance from the circumference of the piston, and they are adapted to form a cylindrical chamber of dimensions coinciding with that of the bosses *a*, *a* upon the connecting rod. In the one section of the piston an aperture is provided through which the shank of the connecting rod passes. This aperture is suitably elongated to permit of the oscillation of the connecting rod. The piston may be composed of stampings which comprise cupped members *d*, *e*, arranged base to base and suitably secured together, the concavities *b*, *c* being provided in the respective bases of the cupped members *d*, *e*. *f* is another cupped member, which is inserted in the cupped member *d* and secured therein. The members *d*, *e* may be stepped at the junctures of their cylindrical walls with their bases, these stepped formations being adapted to provide an annular recess which accommodates a piston ring *g*. (*Accepted February 5, 1919.*)

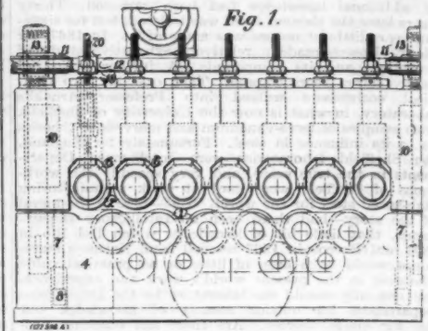
122,447. A. W. Wall, Sheldon, near Birmingham. Internal-Combustion Engines. (3 *Figs.*) January 19, 1918.—This invention comprises a casing for an internal-combustion engine, which casing is manufactured by pressing or stamping, said casing being characterised by a portion which either extends longitudinally of the cylinder for the purpose of locating it, or itself constitutes the cylinder; this cylinder-locating portion extends towards and comprises means for angularly locating the crankshaft. The crank-case consists of two main parts only, being divided in the plane of the axes of the crankshaft and cylinders, and each half of the crank-case is integrally formed with semi-tubular upward extensions *a* constituting the cylinder-locating portions adapted each to embrace one-half of a cylinder and to locate angularly the latter. Between these upward extensions an integral web *b* of metal occurs, the one face of which coincides with the plane of division

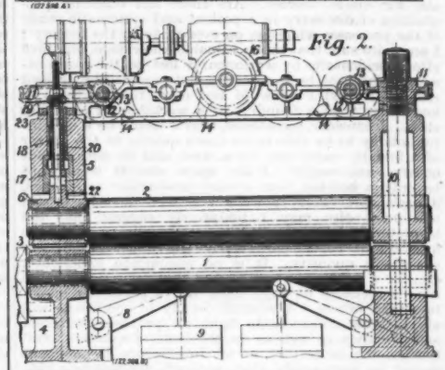


between the two stampings. At the point at which the crank-shaft occurs, this web is formed with a semicircular depression *e* to form a bearing for and to locate angularly the crankshaft. These webs are adapted to be bolted together to form the enclosed crank-case and cylinder supports. The extensions *a* may be enclosed by a separate top bolted to flanges or bosses integrally stamped or formed in the cylinder supports. In one of the two stampings, an elongated indentation *f* is formed at the juncture of each extension *a* with the crank chamber portion. These are adapted to function as the transfer passages, which offer communication between the crank chambers and apertures *g* formed in the cylinder. The other stamping may have a transverse indentation (not shown) extending parallel with the axis of the crankshaft bearings and adapted to form the outer wall of the exhaust conduit, the inner wall of which is formed by the cylinders in which suitable exhaust apertures are provided. (*Accepted February 5, 1919.*)

MINING, METALLURGY AND METAL WORKING.

122,598. A. Sahlin, London. Flattening Rolls. (3 *Figs.*) August 28, 1918.—The invention consists in improvements in rolling devices, known as flattening rolls or mangles, and used for flattening and straightening plates as they leave the plate mill while still at a high temperature. According to the invention, all the upper rolls which are carried in bearings provided in vertical girders supported by weighted levers, can be adjusted together, and also each upper roll can be separately adjusted to compensate for wear without dismantling or even stopping the machine. The lower rolls 1, which are driven by a motor, are supported in bearings 3 of a bedplate 4. The upper rolls 2 are suspended in bearings 6 of two upper girders 5, which are supported by four bars 7 placed at the corners of the girders. Each bar 7 rests on one arm of a pivoted lever 8, the other arm of which carries a heavy weight 9. Strong bolts 10 pass vertically through the girders 5 and are keyed to the bedplate 4. At the top of the girders 5 worm wheels 11, with internal threads engaging with the bolts 10, are rotated for the purpose of raising or lowering the girders by shafts 12 carrying worms 13 gearing with the worm wheels. The shafts 12 are connected by gear wheels 14, and are operated together through reducing gear 16 by a motor 15. The arrangement ensures that the lower ends of the girders 5 will always be in the same horizontal plane. In addition to the general upward and downward movement necessary to accommodate plates of different thickness, means are provided by which each roll can be adjusted so that its bottom face is kept horizontal and in proper relation to the other rolls. For this purpose, for each roll 2 there is an internally-threaded sleeve 17 arranged in a vertical opening in each of the girders 5, and locked in position by a nut. An externally screw-threaded sleeve 18 engages with the threads of the outer sleeve 17 and can be raised and lowered by rotating a head 19. Within the sleeve 18 is a vertical bolt 20 to the lower end of which is keyed a cylindrical extension 22 of the bearing 6; the extension 22 is adapted to slide vertically in the hollow sleeve 17. To adjust the roll, the inner sleeve 18 is screwed down so that when its lower end is held firmly against the top of the extension 22, the roll 2 will be at the required height. A nut 24 engaging with a thread on the upper part of the bolt 20 and resting on the head 19 is then turned, and presses the extension 22 against the lower end of the inner sleeve 18, locking the bolt 20 and sleeve 18 together. In order to remove any roll 2 the girders 5 are raised

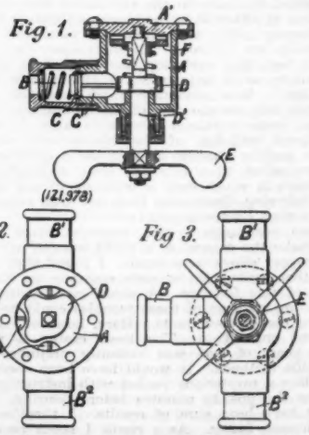




to the top of their upward stroke. The bolt 20 with the bearing 6 is now lowered until the cylindrical extension 22 is clear of the sleeve 17. The cotter 21 can now be removed and the bearing 6 withdrawn sideways, and the roll 2 removed and exchanged without in any way disturbing the adjacent rolls. (*Accepted February 5, 1919.*)

MISCELLANEOUS.

121,978. J. Dewrance, Southwark, London. Multiple-Way Stop Valves. (6 *Figs.*) October 18, 1917.—This invention relates to multiple-way stop valves adapted for use in readily connecting or disconnecting two or more of a series of vessels according to the prevailing requirements. About a central chamber A are arranged three laterally projecting branches, B, B_1, B_2, in each of which is mounted a spring-loaded valve C, two of these branches being arranged opposite one another, whilst the third or intermediate branch is at right angles to the other two, all being in the same plane. The guide stem C_1 of each valve projects into the central chamber A a sufficient distance to admit of its being lifted by anyone of three prominent portions of a cam-shaped body D mounted within the central chamber and carried by a stem D_1, whereby it may be rotated by means of an external attachment E. The latter is preferably



three-armed as shown; each arm corresponding with and serving to indicate the position of one of the prominent and operative portions of the cam-shaped body D. According to the mode of construction illustrated in section in Fig. 1, the cam stem D_1 is prolonged beyond the cam D, and is furnished with a spring-loaded plate F, which rests on the cover A_1 which serves to close the central chamber. The contiguous surfaces of the plate F and cover A_1 are respectively formed with radial ridges having moderately inclined sides; the operation of turning the manual attachment E being in consequence attended by a series of "clicks" which indicate to the operator the extent to which the cams turned and assist in determining the final position desired. It will be obvious that the check surfaces may be otherwise located relatively to the cam. To the outer extremity of each of the valve-fitted branches a connecting pipe is screwed or otherwise attached. (*Accepted January 22, 1919.*)